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THE MOTION OF COMETS WHEN FAR FROM THE SUN.

GEORGE C. COMSTOCK.

FOR POPULAR ASTRONOMY.

It is one of the common-places of popular astronomy that comets do not belong to the solar system but are mere visitors, who come from the region of the fixed stars and after a temporary sojourn return again to the place from whence they came. While the proof adduced in support of these propositions is not entirely convincing we may provisionally assume their truth and inquire how long a time is represented by the adjective in the phrase, "a temporary sojourn;" or in other words, how long a time is required by a comet to come from the region of the fixed stars to the Sun. This time will be half of the entire sojourn, since it is evident that the journeys coming and going are equally long.

The region of the fixed stars is itself not a very well defined territory, but the phrase is usually employed to represent all of the celestial spaces save a limited part immediately surrounding the Sun. We may assume this limited part to be so defined as to include every place that is nearer to the Sun than to any other fixed star, and to exclude every place that has some other fixed star as its nearest stellar neighbor, although it is manifestly impossible in the present state of astronomical science to trace with any considerable accuracy the outlines of the space thus limited. From an examination of a plat of those stars whose parallaxes have been fairly well determined I infer that, without very serious error, we may substitute for this irregularly bounded area, a sphere whose center is at the Sun and whose radius is equal to the distance of the nearest fixed star, *i. e.*, 275,000 times the radius of the Earth's orbit. While this sphere certainly extends farther in the direction of α Centauri than does the irregular space above considered, the resulting error is in the main compensated by a shorter reach in other directions, and in what follows it will be assumed that the region of the fixed stars begins at the surface of this sphere, *i. e.*, at the distance corresponding to a stellar parallax of 0″.75.

To determine the time required by a comet to move from the surface to the center of this sphere under the influence of no other force than the Sun's attraction we note that unless the comet is endowed with an unusual initial velocity its orbit will be a parabola, whose parameter and perihelion distance may be represented by p and q, respectively and in which we shall represent by r and v the radius vector and true anomaly corresponding to the position of the comet at any time, t. The equation of the parabola is

$$r(1 + \cos v) = p \qquad 1.$$

from which we obtain readily the relations,

$$r \cos v = p - r \qquad r \sin v = \sqrt{p(2r - p)} \qquad 2.$$

Also, we obtain by differentiating equation 1 with respect to the time,

$$(1 + \cos v)\frac{dr}{dt} = r \sin v \frac{dv}{dt}. \qquad 3.$$

We have here a differential relation between r and t that will serve to determine the distance of the comet from the Sun at any given time if v can be eliminated from the equation. For this purpose we employ the principle of the conservation of areas, Kepler's Second Law, which, stated in mathematical form, is equivalent to the equation

$$r^2 \frac{dv}{dt} = k\sqrt{p} \qquad 4.$$

where k is the Gaussian constant and, expressed in angular measure, is very nearly equal to the Earth's mean daily motion. In parts of the radius $\log k = 8.2355814 - 10$.

Eliminating v between the last two equations and substituting in place of p its equivalent, $2q$, we obtain

$$k\sqrt{2(r - q)} \cdot dt = r \cdot dr \qquad 5.$$

which when integrated becomes

$$3kt = (r + 2q)\sqrt{2(r - q)} + 9. \qquad 6.$$

When the comet is at perihelion $r = q$ and the first term of the second member of this equation vanishes. If therefore we reckon the time from perihelion passage, the constant of integration, 9, becomes zero and representing the time from perihelion by T we obtain by rationalizing equation 6,

$$9k^2T^2 = 2r^3 \left\{ 1 + 3\frac{q}{r} - 4\left(\frac{q}{r}\right)^3 \right\} \qquad 7.$$

When the comet is at a great distance from perihelion the fraction $q\ r$ is a negligeable quantity and introducing the numerical value of k we may write in place of 7, the simpler form

$$r^3 = 177.64T^2 \qquad 8.$$

where T is to be expressed in years and r in terms of the Earth's mean distance from the Sun. The analogy of this equation to Kepler's Third Law is apparent and it may be considered the equivalent of that law for parabolic motion.

Equation 8, it must be remembered, is only approximate while 7 is rigorously exact, and for moderate distances from the Sun the two equations may furnish appreciably different results. Thus, adopting one of Oppolzer's examples, *Lehrbuch der Bahnbestimmung*, Vol. I, p. 62, I find for a comet 10,000 days from perihelion, in an orbit for which $\log q = 9.5190730$.

From Equation 8.....log r =	1.70813
From Equation 7.....	1.7053242
Oppolzer's value.....	1.7053240

These values of $\log r$ correspond to a distance from the Sun a little less than the diameter of Neptune's orbit and the error of the approximate formula at this distance, is less than one per cent of the entire amount.

At greater distances the error will be proportionately less and we proceed to consider the case in which the comet approximates to stellar distances, introducing for this purpose in place of r the corresponding stellar parallax, π, which is connected with r through the relation

$$\pi r \sin 1'' = 1.$$

Eliminating r from equation 8 by means of this relation we find

$$T = K\,\pi^{-\frac{3}{2}} \qquad 9.$$

where K is a numerical coefficient whose value, in years, is readily found to be, K = 7 028 600, or $\log K = 6.84687$. Into this expression we introduce the value $\pi = 0''.75$, corresponding to the boundary assigned to the region of the fixed stars, and obtain as the time required by a comet to come from this region to the Sun, 10,821,000 years. Since an equal time will be required for the return journey we may say with approximate accuracy that the comet remains within the Sun's domain for something more than twenty million years. As bearing upon the "temporary" character of this period we may compare with it Newcomb's estimate of 18,000,000 years as the past duration of the sun considered as a radiating body.

Strictly speaking the value of T above given relates to a comet that falls into the Sun, *i. e.*, one for which $q = 0$, but it may be applied without very great error to any visible comet. Practically the only comets that can be seen from the Earth are those that come inside of Saturn's orbit but if, for the sake of example, we assume a comet that just fails to come within the orbit of Neptune we shall find from the complete equation, 7, that its value of T exceeds the 10,821,000 years above determined, by about 1-6000th part, *i. e.*, seventeen centuries, and that to terms of this order all parabolic comets require the same period in which to move through the Sun's region.

It may readily be shown that this very long period is due to the extent of the Sun's domain rather than to slowness of the comet's motion in any part of this domain. For, one of the equations of celestial mechanics is

$$V = k\sqrt{\frac{2}{r} - \frac{1}{a}} \qquad 10.$$

which gives the velocity, V, of any satellite of the Sun in terms of the semi-axis major of its orbit, a, and the k and r previously employed. In the case of a comet or other body moving in a parabolic orbit, a is infinite and replacing r, in 10, by the parallax, π, and substituting for k its numerical value we find for the velocity, in miles per hour,

$$V = 208\sqrt{\pi} \qquad 11.$$

Corresponding to this formula we note that at no place within the solar sphere does a comet move with a smaller velocity than 180 miles per hour, and that its average velocity during the entire twenty million years above considered is about twice this minimum velocity.

ANCIENT ECLIPSES AND CHRONOLOGY.

R. W. McFARLAND.

For Popular Astronomy.

In number 70 of this journal was an article under the above heading. The object was to see whether chronology had been aided by eclipses. As an example, the most celebrated of them all—the eclipse of Thales was selected.

An investigation was made of the date of that eclipse as given by some modern astronomers, and by eminent writers both of ancient and of modern times, and of several nationalities. It

appeared that the estimates of the date differed by more than forty years. In number 84 appeared a short supplementary article in which it was stated that three other dates had been found, making the whole number of different dates twelve, and extending the time to eighty-six years.

In number 87, Professor Stockwell had an article criticising mine, and therein he claims to have reduced the time to *seven* years, and dates to *two*, instead of twelve as shown by my two articles.

At first reading it seemed best not to make any rejoinder; but on maturer reflection it is deemed proper to notice a few points to see whether they are well taken or not.

First: He says that Professor McFarland "does not attempt to apply it (Herschel's criterion) to the determination of the date of the eclipse of Thales." On the contrary, the burden of the whole paper was concerned with the two points of the criterion, —which two parts, in substance are as follows, viz.: 1st, that the eclipse be "completely identified," and 2d, that the exact interval of time between the event and the eclipse be given. Herodotus who wrote of this eclipse about one hundred and fifty years after it occurred, says the eclipse put an end to the battle. This statement satisfies one part of the criterion. The second step was to identify the eclipse. For this purpose I applied to the astronomers; and found that the two men—Baily and Airy—deemed most competent to settle that question, differed in their dates about twenty-five years. The astronomers thus failing to "identify" the eclipse, recourse was had to historians both ancient and modern, and of several nationalities. But these differed by a much wider interval than the astronomers. The necessary conclusion was that the date of the eclipse is not established,—a conclusion as evident as the truth of a mathematical axiom.

Second: It is stated that subsequently Mr. Baily regarded his computations as of small value, because the same lunar tables "completely failed to produce an eclipse such as was described by the historian—the eclipse of Agathocles whose date was known." This reason has no force at all. All men who have examined Roman and Greek chronology, agree with Herschel as to "the confusion of dates, and the irreconcilable contradictions which historical statements too often exhibit." The date of the eclipse of Agathocles is no better known than that of Thales: all ancient dates, both Roman and Greek, are subject to similar uncertainty.

This argument or statement, then, so far as it has any force, is an argument against the reliability of the lunar tables. Further on this second point,—Herschel seems not to agree with Baily as to the value of the latter's calculations. The two men were intimately associated in astronomical work. Baily died in 1844, and seven years afterwards, in 1851, Herschel published the fourth edition of his "Outlines of Astronomy." In this book the note is given which mentions "the remarkable calculations of Mr. Baily relative to the celebrated solar eclipse which put an end to the battle between the kings of Media and Lydia, B. C. 610, September 30." Evidently Herschel considered Baily's work as worthy of confidence; and this date must not be set aside, for other men had fixed on the *same* year; and I gave merely the number of years, and said nothing of the number of persons who had fixed on the *same* year. But even if this year were set aside, as it cannot be, we find another to take its place. See the January, 1902, POPULAR ASTRONOMY, p. 23, the correspondent saying "to me it is evident that B. C. 547, Oct. 23 is the celebrated 'eclipse of Thales' . . . "—a small difference of sixty-three years from the date assigned by Baily.

Third: No one supposes that Cicero, or Pliny, or Usher, or Scaliger ever computed eclipses, and a denial of their attainments in this regard has nothing to do with the question at issue. They wrote as historians or literary men,—not as astronomers.

Fourth: The criticism further states that "Professor McFarland was seeking data for the satisfaction of chronology." My object was entirely different as stated above.

Fifth: After mentioning the calculations of Professor Newcomb in regard to this eclipse, the critic further says, "It would therefore seem to follow from the calculations of these three astronomers, (Baily, Airy and Newcomb), that there is no astronomical evidence of any eclipse of Thales." This is a curious assertion, but it seems to accord exactly with the conclusion which I have reached in my first article, viz., that chronology had received no aid from ancient eclipses.

Sixth: Professor Stockwell further says "that the number of possible eclipses which may, or rather have been assigned to that event, is reduced from nine to two, and the interval of uncertainty is reduced from eighty-six to two years." No one has said anything about *nine* "possible eclipses." I showed that *twelve* different dates had been assigned to the *one* eclipse by different writers; and neither the number of dates, nor the long interval of eighty-six years, has been set aside by anything in

Professor Stockwell's article. To ignore a statement does not refute it, and mere assertion fails in the quality which constitutes proof. The article further says "Professor McFarland . . . . reasons about the matter as if they [the nine eclipses] were all visible at the same place and satisfied equally well the narrative of the historian concerning them." There is not a word of any such reasoning in anything I have written. The statement is singularly wild and far from the facts, as any one can see on examination.

Seventh: Further, he says, "It would seem to be a fact that he [Thales] predicted the only one that occurred during his life time after witnessing one." There is not the slightest historical evidence in Herodotus or elsewhere that Thales witnessed an eclipse before he made his prediction;—and equally is evidence wanting that he saw even the eclipse which he did predict. It would be difficult to find a case of more careless writing than the above; and cynical people may think that "dismal failure" may be no uncommon thing.

Many other points were marked for notice, but the preceding must suffice as specimens of mistakes, errors, slips, etc., more numerous than the pages on which they were written.

Further, the dates of historical events have nothing to do with eclipses. They depend on contemporary records; and from the days of Herodotus, "the father of history," to the present time, writers of history when giving dates never refer to eclipses as fixing those dates, and even if an eclipse is referred to, it is merely as an incident. Besides, as the ancient historians wrote histories without dates, it pleased some modern scholars who were troubled by the "confusion of dates and irreconcilable contradictions," to call on astronomers for help,—or astronomers unsolicited proposed to render aid;—with what result those who have read these articles can judge. Where there is no fixed epoch, to say "in the sixth year of the Peloponesian war," or "in the seventh year of Jehu," is equivalent to no date at all.

As before stated, early writers had no fixed epoch from which to reckon. The Olympic Period and the Founding of Rome were not so used for more than five hundred years after those dates to which they were subsequently referred. Different writers assigned different dates; and Professor Stockwell puts the Olympic Period one year earlier than the date which for centuries has been generally accepted. And the death of the Emperor Augustus,—a relatively late event,—he puts one year later than that which had stood for ages, unchallenged, so far as I know.

Inasmuch as the ablest astronomers and the most celebrated historians fail to agree, there is small prospect of harmony unless there is universal consent to discard all writers but one, and follow his sole guidance: a proceeding not likely to occur till the advent of the long talked-of millennium;—and should it take place even then, men of science and of sense might say with Antony:

> "O Judgment, thou art fled to brutish beasts.
> And men have lost their reason!"

SUPPLEMENTARY REPORT ON NON-EUCLIDEAN GEOMETRY.

GEORGE BRUCE HALSTED.

CONTINUED FROM JANUARY NUMBER PAGE 30.

"The angles at the extremities of two equal perpendiculars are either right angles, acute angles, or obtuse angles, at least for restricted figures. We shall distinguish the three cases by speaking of them as the hypothesis of the right angle, the hypothesis of the acute angle, and the hypothesis of the obtuse angle respectively."

Saccheri's Proposition III. is: "If two equal straights, AC, BD, stand perpendicular to any straight, AB; I say the join CD will be equal, or less, or greater than AB, according as the angles at CD are right, or obtuse, or acute."

This Manning paraphrases as follows:

"The line joining the extremities of two equal perpendiculars is at least for any restricted portion of the plane, equal to, greater than or less than the line joining their feet in the three hypotheses respectively."

In the same way is paraphrased Saccheri's Prop. IV., the converse of III.

Saccheri's Corollary about quadrilaterals with three right angles is given by Manning on page 12.

Saccheri's Prop. V. is: "The hypothesis of right angle, if even in a single case it is true, always in every case it alone is true."

In giving this, Manning has: 'If the hypothesis of *a* right angle,' etc., evidently a slip for his usual *the* right angle. Of course the Latin original, of which I have, so far as I know, the only copy on this continent has no article.

Prop. VI and Prop. VII are combined by Manning on p. 13.

Prop. IX is reproduced on page 14.

Prop. X is given on p. 9.

In Prop. XI Saccheri with the hypothesis of right angle demonstrates the celebrated Postulatum of Euclid, thus showing that his hypothesis of right angle is the ordinary Euclidean geometry.

Manning says, p. 27: "The three hypotheses give rise to three systems of geometry, which are called the parabolic, the hyperbolic, and the elliptic geometries. They are also called the Geometries of Euclid, of Lobachevski and of Riemann." Now Saccheri in his demonstration of Prop. XI makes, almost in the words of Archimedes, an assumption, introduced by the words 'it is manifest,' which we now call, for convenience, Archimedes' Axiom. In his futile attempts at demonstrating the parallel-postulate, Legendre's theorems on the angle-sum in a triangle. They are:

1. In a triangle the sum of the three angles can never be greater than two right angles.

2. If in any triangle the sum of the three angles is equal to two right angles, so is it in every triangle.

In addition to assuming the infinity or two-sidedness of the straight, in his proofs of these theorems Legendre uses essentially the Archimedes Axiom. Thence he gets that the angle-sum in a triangle equaling two right angles is equivalent to the parallel-postulate, all of which is really what Saccheri gave a century before him, now just reproduced by Barbarin and Manning, as before by De Tilly. Even Hilbert in his 'Vorlesung ueber Euklidische Geometrie' (winter semester, 1898-99), for a chance to see Dr. von Schafer's Authographie of which I am deeply grateful to Professor Bosworth, gives the following five theorems and then says: "Finally we remark, that it seems as if each of these five theorems could serve precisely as *equivalent of the* Parallel Axiom." They are:

1. The sum of the angles of a triangle is always equal to two right angles.

2. If two parallels are cut by a third straight, then the opposite (corresponding) angles are equal.

3. Two straights, which are parallel to a third, are parallel to one another.

4. Through every point within an angle less than a straight angle, I can always draw straights which cut both sides [not perhaps their prolongations.]

5. All points of a straight have from a parallel the same distance.

But since then a wonderful discovery has been made by M. Dehn.

It was known that Euclid's geometry could be built up with-

out the Archimedes axiom. So arises the weighty question: *In such a geometry do the Legendre theorems necessarily hold good?*

In other words: Can we prove the Legendre theorems without making use of the Archimedes axiom?

This is the question which, at the instigation of Hilbert, was taken up by Dehn.

His article was published July 10, 1900, (*Mathematische Annalen*, 53 Band, pp. 404-439).

Dehn was able to demonstrate Legendre's second theorem without using any postulate of continuity, a remarkable advance over Saccheri, Legendre, De Tilly.

But his second result is far more remarkable, namely, that Legendre's first theorem is indemonstrable without the Archimedes axiom.

To prove this startling position, Dehn constructs a new non-Euclidean geometry, which he calls a 'non-Legendrean' geometry, in which through every point an infinity of parallels to any straight can be drawn, yet in which, nevertheless, the angle sum in every triangle is greater than two right angles.

Thereby is the undemonstrability of the first Legendre theorem without the help of the Archimedes axiom proven.

Dehn then discusses the connection between the three different hypotheses relative to the sum of the angles [the three hypotheses of Saccheri, Barbarin, Manning] and the three different hypotheses relative to the number and existence of parallels.

He reaches the following remarkable propositions:

From the hypothesis that through a given point we can draw an infinity of parallels to a given straight it follows, if we exclude the Archimedes axiom, *not* that the sum of the angles of a triangle is less than two right angles, but on the contrary that this sum may be (*a*) greater than two right angles, (*b*) equal to two right angles.

The first case (*a*) is proven by the existence of the non-Legendrean geometry.

To demonstrate the second case (*b*), Dehn constructs a geometry wherein the parallel-axiom does not hold good, and wherein nevertheless are verified all the theorems of Euclidean geometry; the sum of the angles of a triangle is equal to two right angles, similar triangles exist, the extremities of equal perpendiculars to a straight are all situated on the same straight, etc.

As Dehn states this result: There are non-Archimedian geometries, in which the parallel-axiom is not valid and yet the angle-sum in every triangle is equal to two right angles.

Such a geometry he calls *semi-Euclidean.*

Therefore it follows that none of the theorems, the angle-sum in the triangle is two right angles, the equidistantial is a straight, etc., can be considered as equivalent to the parallel-postulate, and that Euclid in setting up the parallel-postulate hit just the right assumption.

This is a marvellous triumph for Euclid.

Finally Dehn arrives at this surprising theorem:

From the hypothesis that there are no parallels, it follows that the sum of the angles of a triangle is greater than two right angles.

Thus the two non-Euclidean hypotheses about parallels act in a manner absolutely different with regard to the Archimedes Axiom.

THE ZODIACAL LIGHT.

ARTHUR K. BARTLETT.

For Popular Astronomy.

At this season of the year, on every clear evening during the absence of the Moon, there is visible in the western heavens after sunset, a strange illumination known as the zodiacal light, which very much resembles the faint glimmer of the aurora borealis, and might easily be mistaken for that interesting phenomenon of the northern sky, by those unacquainted with astronomy, were it not for the position it maintains and the singular form it invariably presents to the observer. This remarkable celestial spectacle, which has doubtless been noticed by every person who enjoys an occasional survey of the heavens at this season, has attracted the attention of astronomers from time immemorial, but has never been satisfactorily explained, and still remains an enigma in astronomical science, though many ingenious theories have been advanced to account for it, none of which are yet accepted with confidence as a solution of the mysterious apparition.

The form of the zodiacal light is that of a cone or pyramid, having a rounded top, with its base directed toward the Sun, and its axis nearly in the plane of the ecliptic. Its light is like that of the Milky Way, or that of the faint twilight, thin enough to let the stars be seen through it, and seems to surround the Sun in the form of a lens, the plane of which is nearly coincident

with that of the Sun's equator. The apparent angular distance of its vertex from the Sun varies from forty to ninety degrees, and the breadth of its base, perpendicular to its axis, from eight to thirty degrees. It is believed to extend beyond the orbit of the planet Mercury, and even as far as that of Venus, but—with occasional exceptions—never so far as the orbit of the Earth.

This wonderful illumination is not mentioned by any of the early writers on astronomy, though it certainly could not have escaped the notice of the Arabian and Grecian astronomers. An ancient Aztec manuscript preserved in the Bibliotheque du Roi, at Paris, is said to contain an account of a mysterious light that was visible for forty consecutive nights in the year 1509, and which Montezuma regarded as an omen of his downfall. This is now believed to have been an unusually luminous zodiacal light, as it is recorded to have been seen in the immediate vicinity of the Sun when it was below the horizon. The phenomenon was first noticed in Europe by Professor Childrey, in the year 1661, but it was afterward more particularly observed and described by the celebrated astronomer Dominic Cassini, in the spring of 1663. Humboldt observed the various intensities of this wonderful light in the tropical regions; and he saw it flicker and wane from a very strong to a pale light, and then suddenly shoot up again as bright as before. A peculiar gleam similar to the zodiacal light, if not identical with it, is described by John Christopher Sturmius, a German philosopher, who flourished during the last half of the seventeenth century. He called it Heliocometes, or comet of the Sun, because the light, which he sometimes observed at sunset, appeared like a large column of light attached to the Sun, like the "tail" to a comet.

The Rev. George Jones, of the United States Navy, a member of the corps belonging to the Japan expedition, made numerous observations on the zodiacal light, showing that, in that climate, "it never fails to be seen when the Moon and clouds do not interfere." Biot thought that the zodiacal light might be in some way connected with the Earth, and by repeated experiments he found that it gave more heat than the tail of a comet. When at the summer solstice, according to the observations of the Rev. Mr. Jones, the zodiacal light was visible from 11:00 P. M. until 1:00 A. M. in both the eastern and western horizon, with their apexes approaching each other. From the facts which he accumulated in regard to this singular exhibition, Mr. Jones concluded that the light was a nebulous ring surrounding the Earth, in which the meteors and shooting stars may have their origin.

Professor Pierce concurred with Mr. Jones in his theory, and Professor Gould thought that Mr. Jones' observations threw more light on the nature of this strange illumination than all other astronomers before him. But this theory has long since been exploded, and is now regarded as absurd in the light of more recent researches; for, whatever its nature and constitution may be, the zodiacal light is known to be a solar appendage, and in no way connected with the Earth or its atmosphere.

The zodiacal light is so-called from the fact that its axis is inclined to the horizon in the direction of the zodiac, the broad belt or zone within which the Sun and major planets perform their revolutions over the firmament. The season most favorable for observing this celestial glimmer is when its direction is most nearly at right angles with the horizon, and it is least obscured by the twilight. In northern latitudes this occurs in February and March for the evening, and in October and November for the morning, when it is visible in the east just before dawn. At places favorably situated, even in the temperate zone, it may be seen at almost every season, and on or near the equator it increases in intensity and height, and it can be observed throughout the year. In our climate, the light is rather more intense than that of the Milky Way, and also much more uniform. It is brightest in the parts nearest the Sun, and in its upper part its light fades away by insensible degrees, until it becomes too feeble for distinct vision, so that different observers, at the same time and place, assign to it different limits, according to their respective powers of vision; but the distance to which the light extends from the Sun varies with the season of the year, and the condition of the atmosphere. Peculiar undulations and flashings resembling the aurora have been noticed in it when the sky was unusually clear and the Moon absent.

The light really extends out on each side of the Sun, and lies nearly in the plane of the ecliptic; and the direction of the axis of the cone of light, if prolonged below the horizon, always passes through the Sun. Professor Newcomb says: "It lies very nearly in the plane of the ecliptic, but its exact position is difficult to determine, not only owing to its indistinct outline, but because in northern latitudes the southern edge will be dimmed by the greater thickness of atmosphere through which it is seen, and thus the light will look farther north than it really is. The nature of the substance from which this light emanates is entirely unknown."

In our latitude the zodiacal light can be seen distinctly only

after the evening twilight during the months of February and March, and before the beginning of the morning twilight in October and November; for at those times it stands most erect above the horizon, and is therefore farthest removed from the thick vapors and twilight. It is also faintly visible during the month of April, in the evening, and about the time of the winter solstice it may be seen in the morning, but it is seldom perceived in summer, on account of the long twilights at that season. It is more easily and more frequently observed in tropical countries, and particularly near the equator, than in our own country, because in those regions the obliquity of the equator and zodiac to the horizon is less, and the duration of twilight is much shorter.

Arago's *Popular Astronomy* contains the following passage regarding this singular phenomenon: "Professor Mairan asserts that this species of light had been already seen by the ancients. Nicephorus, says the author of the treatise on the 'Aurora Borealis,' relates that after the capture of Rome by Alaric, a great eclipse occurred during which there was seen in the heavens a light which had the form of a cone. The Greek historian treats as ignorant persons those who pretend that this light was the tail of a comet." Arago adds to this that it is remarkable no trace of the zodiacal light, at least with its aspect of an "iron lance," has been seen by modern astronomers during total eclipses of the Sun, and finds an explanation in the circumstance that the light is seen only in the twilight, when stars of the third and fourth magnitude are easily perceived by the naked eye, whereas, the corona of the total eclipse throws light enough into the atmosphere to render invisible, in its neighborhood, the stars of that magnitude. Yet many eminent astronomers think that the zodiacal light ought to be looked for in every total eclipse of the Sun, and the atmospheric condition might sometime be such as to render it visible. If ever seen during a total eclipse, it would probably appear as faint and conical lights, extending in two diametrically opposite directions, with their bases toward the Sun.

The late Professor Steele, in his excellent work on astronomy, thus refers to the interesting spectacle: "If we watch the western horizon in March or April, just after sunset, we will sometimes see the short twilight of that season illuminated by a faint, tremulous light, of a conical shape, flashing upward often as high as the Pleiades. In September and October, at early dawn, the same appearance can be detected near the eastern horizon.

The light can be seen in this latitude only on the most favorable evenings, when the sky is clear and the Moon absent. Even then, it will be frequently confounded with the Milky Way or auroral lights. At the base it is of a reddish hue, where it is so bright as frequently to efface the smaller stars. In tropical regions the zodiacal light is perpetual, and shines with a brilliancy sufficient, says Humboldt, to cast a sensible glow on the opposite part of the heavens."

In the equatorial regions, at high elevations, the zodiacal light has been seen at all hours of the night to extend entirely across the heavens, from the eastern to the western horizon, in the form of a pale, luminous arch, having a breadth of thirty degrees, and there is said to be in it, at a point exactly opposite to the Sun, a patch a few degrees in diameter of slightly brighter luminosity, called the gegenschein or counter glow. This faint light is seen by the naked eye only in the zodiac and always about 180 degrees from the Sun, and the phenomenon is as great a mystery as the zodiacal light itself. A recent explanation is that it is due like the luminous redness of the eclipsed Moon, to the refraction by the Earth's atmosphere of sunlight, which is made to converge in the shadow of the Earth and reflected—in the one case by the Moon and in the other by the meteor dust of space, or by clusters or shoals of small interplanetary bodies, too minute and faint to be seen individually. This strange patch of light, which is one of the most interesting of astronomical puzzles, may be best seen in September and October, and affords an excellent test of ones powers of vision. The late Professor Proctor, in his "Essays on Astronomy," presents an interesting paper to which we refer the reader for a learned and exhaustive discussion of the subject. He begins his remarks by saying: "It cannot but be regarded as a remarkable circumstance, that the nature of the zodiacal light should, in the present state of astronomy, continue to be a *quaestio vexata*." Professor Chamber's *Hand-Book of Astronomy*, Vol. I, also contains an excellent description of the spectacle, with the various theories and observations pertaining to it.

As the illumination always accompanies the Sun, it is evident that it can not be a terrestrial appendage. The fact that its aspect and position are the same in different latitudes, and its axis is situated in the same part of the heavens, from whatever locality the light is observed, indicates that it is too far away from the Earth to have an appreciable displacement from the effects of parallax. It is the opinion of most astronomers that

the phenomenon is caused by a faint, cloud-like ring, perhaps a meteoric zone, that surrounds the Sun, and only becomes visible to us when the Sun is below the horizon. The theory now generally accepted attributes the illumination to sunlight reflected by an immense number of meteoric bodies—very small and perhaps thrown off by comets—revolving around the Sun nearly in the plane of the ecliptic, most of them being within the Earth's orbit, forming a thin, flat sheet like one of Saturn's rings, and extending far beyond the orbit of the Earth.

These meteors are like those which the Earth is constantly encountering in space, and which, on entering our atmosphere, become visible to us as "shooting stars." In the zodiacal light they are too small to be seen separately, even with a large telescope, but they combine in unknown millions, according to this theory, to reflect to our eyes the peculiar light in question, borrowing it from the Sun, around which they all revolve, probably in elliptical orbits like the planets. All of these meteors together would, by their reflection, produce the pale, diffused light, which we observe in the west at this season of the year. This meteoric zone, if it extends beyond the Earth's orbit, must have a diameter of at least 200,000,000 miles. Professor Young says: "While this theory, however, is at present more generally accepted than any other, it cannot be said to be established. Some are disposed to consider the zodiacal light as a mere extension of the Sun's corona, whatever that may be." It is a singular fact to be regretted that, as Professor Chambers well remarks, "little or no progress has been made during recent years in elucidating the theory of the zodiacal light; and this is the more remarkable considering the development of all other branches of astronomy."

Recent observations with the spectroscope, that marvelous instrument of science, have shown that the zodiacal light gives a continuous spectrum, which indicates that it is composed of solid masses, and shines by reflecting to us the Sun's light. The subject is certainly worthy of attention, and future observations may not only throw light on this particular phenomenon, but present to our contemplation a singular variety of celestial bodies with which we were formerly unacquainted. If our Sun could be viewed from one of the other stars, it would doubtless appear to be surrounded by a nebulous light, similar to that in which some of the "fixed" stars appear to be enveloped, as seen from the Earth.

BATTLE CREEK, Mich.

EXPLANATION OF THE SUPPOSED SIGNALS FROM MARS OF DECEMBER 7, AND 8, 1900.*

PERCIVAL LOWELL.

1. On a certain morning in December, 1900, paragraphs appeared in the papers throughout the United States with the startling announcement that Mars had been signaling the Earth the night before. Lights, it was reported, had suddenly shone out upon the surface of the planet, lasted for a time and then vanished. What the signals meant was not so forthcoming. Vividness of headline made up for meagreness of news.

Interest was not confined to the United States. Reportorial inquisitiveness was as rife in the Old World as in the New, and Europe was behind America in the receipt of the message only the time necessary for its transmittal.

2. To broaden one's horizon is a good thing; and to broaden it beyond the bounds where horizon itself disappears, a still better one. But the broadening is apt to come not in a way we expect, and to prove the more broadening for that reason. I hope, therefore, not seriously to lessen interest in the phenomena by saying that they were certainly not what they were popularly taken to be, and were with equal certainty much which was not supposed and is quite as interesting.

The innocent cause of the misrepresentation was a dispatch sent from Flagstaff to the writer and communicated by him through the usual channels to the astronomical world. The signaling part of it was a tale added by journalistic ingenuity at the time that profession became possessed of the subject. The original dispatch read:

> "Projection observed last night over Icarium Mare, lasting seventy minutes."
> (Signed) "DOUGLASS."

3. Projections in the case of one heavenly body, the Moon, are not unfamiliar objects. On almost any night when that body shows a terminator, that is a sunset or sunrise edge, a keen eye can detect one or more of them along it without telescopic aid. With Mars the phenomenon is much less common and, though many such projections have in the last few years been seen upon the planet, the sight is one of some rarity.

4. In the case of the Moon it is possible to find out the cause of the projections. By magnification through a telescope the

* Read December 6, 1901. Reprinted from *Proc. Amer. Philos. Soc.*, Vol. XL, No. 167.

little knob that breaks the otherwise uniform boundary of light and shade is seen to resolve itself into the tip of a mountain peak or the summit of a crater wall, which catches the light while the lower ground at its foot is plunged in shadow, and so seems to project beyond the rest of the disk. With Mars no such forthright determination of the problem is possible. For no magnification we can apply is potent enough to disclose of itself the character of the country. We are, therefore, obliged to reason upon what we see.

5. Taking lunar analogies for guide, it was generally inferred that the martian projections too were due to mountain peaks. From which of course it followed, or as one may say preceded, that there were mountains on Mars. But the Flagstaff observations of 1894 showed that, on general principles, this was very improbable. The study of the surface markings led the writer to a general theory about the character of the planet, in which mountains not only found no place but to which they were decidedly opposed. At the same time that the theory suggested itself, but independent of it, Mr. Douglass observed several projections, and conceived and published another explanation for them, and this one proved consonant with what the theory demanded, to-wit: that, instead of being due to mountains upon the planet's surface, they were due to clouds floating in the planet's air. He showed that the observations were thus much better explained; in fact, that his observations could hardly be accounted for with probability on the mountain hypothesis at all.

6. The opposition of 1894 was very prolific of projections, over four hundred being seen at Flagstaff in the course of nine months. The next opposition was not so good; while in that which has just passed, that of 1900-1, only two were detected. It was these two which gave rise to the notion of signals from the planet.

Now the variability in the number seen at different oppositions should have materially shaken faith in the mountain explanation. Mountains are permanent affairs, and if they be high enough to catch the light and show as protuberances at one time they should do the like at another. The change in the inclination of the disk would not materially alter their visibility. But it is one of the humorous anomalies about human nature that general reasoning affects minds so little when applied to unfamiliar matters, while in familiar ones it is the guiding principle of life.

7. Argument from the two projections of the last opposition is, on the other hand, particular. Although they were but two in

number, testimony in the case is very much to the point. Indeed, their isolated character helps to make their cogency the clearer.

On December 7, at $16^h\ 15^m$ S. M. T., Mr. Douglass suddenly noticed a projection on the terminator of the planet, a little to north of the Sabæus Sinus. The phase loss at the time was 36°.4. As he continued to watch it the projection increased. The distance of its tip from the edge of the terminator passed successively through the values ⅔, 1, 1⅓ and 1½ of a thread; the thread used being the stationary spider's thread of the micrometer. Meanwhile he was busy taking the position angle of the tangent to the terminator, at the point directly under it, at intervals of a few minutes. His observations, recorded in detail in the observing book, are as follows:

RECORD OF DECEMBER 7, 1900.

Th. = thread; P. A. = position angle.

1900			
Dec. 7	16^h	15^m	Projection over Sinus Sabæus; P. A. tang. to terminator 183°.2.
		22	Projection continues (sketch). Height = ⅔ Th.
		24	P. A. terminator tang. 185°.5.
		26	P. A. terminator tang. 184°.3.
		30	Projection continues; ½ to ¾ Th. in height.
		34½	P. A. terminator tang. 182°.4.
		37½	Ht. 1 Th.; no other irregularities on terminator.
		39	P. A. 182°.0.
		41	P. A. 184°.7
		42½	Rather bright on terminator near north cap at P. A. 238°.0.
		44	Projection continues; terminator otherwise regular.
		46	P. A. 183°.8.
		51	(After spell of seeing 0) projection then of this form: (sketch). Height 1⅓ Th.
			P. A. 183°.9.
		55	Projection there; flatter?
		59	Projection there; flatter?
	17	6	Projection there (after spell bad seeing) (sketch); possible separation. Height 1½ Th.
			P. A. 186°.2.
		19	Think projection is very small; at times thought it gone. Now ⅓ Th. (sketch).
		22	Projection certainly there: I get this form: (sketch) Sinus Sabæus? Very low, say ¼ Th.
			P. A. 185°.3.
		30	Think the projection has gone or else it is very slight; if it is there its P. A. is 186°.0.
		35	Projection undoubtedly gone.

8. On the next night he found the terminator perfectly regular until $15^h\ 44^m$ S. M. T., when he recorded: Terminator regular,

but suspicious white N. of Icarium Mare. Icarium Mare is a name given to the dark marking running from the forks of the Sabæus Sinus to the Hammonis Cornu, and formerly included under the general designation of the Sabæus Sinus. Four minutes later he noted: Projection just started N. of Icarium Mare. There then followed an almost exact repetition of the previous night's experiences, as will be seen from the transcript of the observations.

RECORD OF DECEMBER 8, 1900.
Th. = thread; P. A. = position angle.

1900.			
Dec. 8	15h	44m	Terminator regular, but a suspicious white N. of Icarium Mare.
		48	Projection just started N. of Icarium Mare.
		50	At P. A. 186°.3. Ht. ½ Th.
			All, so far, was with eyepiece .89.
			I now put in ¾ ep.
		58	Projection more conspicuous. Ht. ⅔ Th.
			P. A. 184°.8.
	16	02½	Projection. Ht. ⅔ Th. shows more easily in this ep. than .89.
		16	Projection at P. A. 187°.7; seeing good for limb and terminator.
		20	The projection looks separated from term; seeing not good enough to assume this (sketch).
		25	Projection looks separated in good seeing. Ht. 1½ Th., and half of this is separated (sketch).
			P. A. 188°.1.
		34	Projection P. A. 187°.0; in ½ inch; seeing poor.
		44	Projection probably there at P. A. 187°.7, and of this form (sketch) and faint; seeing is constantly too poor to judge well.
		47	Projection; think it is there as described. The terminator has been otherwise regular at all observations.
		50	See 1—2. Think projection is there, low and faint, and also a whitish region on adjoining disk.

9. On reducing and comparing the observations of the two nights, it appears at once that they do not refer to the same point or points upon the planet. On the first night, at the time of the appearance of the projection, the longitude of the centre of the disk was 26°, at the time of its disappearance 44°, while on the next evening the longitudes were respectively 10° and 25°. Not only were the two positions not the same, but they were separated from one another by at least sixteen degrees of longitude.

10. On looking up the records of the first night, it appears that the planet, previous to the detection of the projection, was under continuous observation from $14^h\ 10^m$ to $15^h\ 45^m$ S. M. T.,

or from the time the longitude of the centre was 355° to the time it was 18°. During this interval there are two specific records that the terminator was free from irregularity, one at $14^h\ 31^m$, the other at $14^h\ 45^m$; and from the nature of the observations it is presumable that any projection occurring in the interval would not have escaped notice. We may then fairly infer that the projection seen on December 8 did not exist in that position on December 7.

11. On December 8 observations ceased at $16^h\ 50^m$, but on the 12th of the month the terminator was carefully scrutinized from longitude centre 298° to longitude centre 13° at intervals, such that no projection of the duration of those of the 7th and 8th could have passed it without being seen. No irregularity was detected. The projection of December 8, therefore, did not exist *in situ* on the 12th.

12. Furthermore, when the rotations of the planet and the Earth brought the two bodies again into corresponding positions at corresponding hours on January 12, the terminator was scanned by Mr. Douglass from $13^h\ 48^m$ to $15^h\ 35^m$, or from longitude centre 15° to longitude centre 41°, without revealing any irregularity. The phase loss was then 27°, as against 36° in December. So that nine degrees should be deducted from these figures to make them comparable. It thus appears that on this date both projections should have been visible, one after the other, had they still existed. Neither was seen. Nor was any projection seen at any other time during the opposition. Permanences like mountains, therefore, could not have caused them without doing violence to the observations.

From the impermanency of place of the projections it is clear that they could not have been fixed to the planet's surface—that is, they could not have been mountains. We are left, therefore, with the alternative that they were a something floating in the planet's air capable of reflecting light, or in other words clouds. Secondly, from the similarity of their appearances, we infer that they were the same clouds which had shifted their position during the twenty-four hours that elapsed between their apparitions. They may, of course, have been wholly distinct condensations of vapor which happened to agree in behavior. The probability of this we shall now investigate by considering the phenomena more in detail.

13. It is necessary to begin by determining their height, for it will be found that this height enters as a function into the equations of position. If we call

d = the perpendicular distance of the tip of the projection from the terminator;

$P—P.\ A.$ = ϕ = angle between the tangent to the terminator and the axis of rotation;

E = the angle of the phase;

A = the phase latitude, that is the latitude reckoned from the phase equator;

a = the radius of the disk in seconds of arc;

a_0 = the radius of the planet in miles;

x = the angle subtended at the centre of the disk between the tip of the projection and the point on the terminator at the same phase latitude,

we shall have

$$\tan x = \frac{d}{\cos \phi \sin E.\ a.\ \cos A}$$

and h = height will be

$$h = \sec x - 1.\ a_0 \cos^2 A$$

Performing the numerical operations, we find for the height on December 7,

$$h = 13.4 \text{ miles.}$$

and on December 8,

$$h = 13.6 \text{ miles.}$$

14. For the calculation of position we proceed as follows:

Let θ = angle which the line from the centre of the phase ellipse to the point upon the terminator perpendicularly under the projection makes with the minor axis of that ellipse. Let r = distance from the centre of the disk to this point. The minor axis has for value $r \cos E$, the major axis being r. By a property of the ellipse we have

$$\tan \theta = \frac{a^2}{b^2} \tan \phi = \sec^2 E \tan \phi$$

from which we find θ. To find r we have from the equation of the ellipse

$$r^2 = \frac{a^2}{\sin^2 \theta + \frac{a^2}{b^2} \cos^2 \theta}$$

from which, knowing θ, the value of r follows.

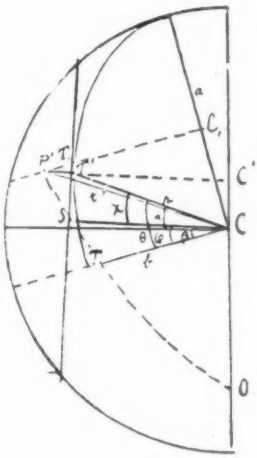
The distance t from the centre to the tip of the projection may now be got by solving the plane triangle whose sides are d, r and t. For d is given, r is now known and the angle included between them is $180° - \chi$ where

$$\chi = \theta - \phi$$

and this also is known.

t would give us the projected place upon the visible disk of the tip of the projection, if the projection were on the surface of the planetary sphere. As it is in reality raised above it, we must apply a correction depending upon the height of the projection. It is for this reason that the height must first have been found. Perhaps the neatest way is the one adopted by Mr. Manson, who performed the numerical computations, that of simple projection, which gives

$$t_1 = \frac{a}{a + h} t$$



$\tan\theta = \frac{a^2}{b^2}\tan\varphi$?

$r' = \frac{a^2}{\sin^2\theta + \frac{a^2}{b^2}\cos^2\theta}$

$t^2 = r'^2 + k^2 + 2rk\cos\chi$

$\frac{\sin TCP'}{\sin\chi} = \frac{k}{t}$

$\chi = \theta - \varphi$

$\alpha = \theta - \beta$

$C = 90° + \alpha - TCP'$

Knowing t and also the angle in the plane triangle opposite the side d, which we may call D, we have a spherical triangle for the determination of the latitude and longitude of the point on the

sphere directly under the projection. In this triangle we know the side t, whose value in angular measure is cos t; the side $(90° - B)$, which is the angle between the pole of the planet and the centre of the disk; and the angle between the two, which is

$$C = 90° - (Q - 270° - P) + \theta - D$$
$$= P - Q + \theta - D$$

where P and Q have the meanings of Crommelin's ephemeris for the planet.

We then have the latitude, l_1, from

$$\cos l_1 = \cos t_1 \sin B + \sin t_1 \cos B \cos C$$

and the longitude, λ, from

$$\frac{\sin(\lambda - \lambda_1)}{\sin C} = \frac{\sin t_1}{\sin T_1}$$

The results are:

PROJECTION DECEMBER 7, 1900.

TABLE I.

Date.	h.	m.	P. A. °	d.	Lat. °	Long. °
Dec. 7	16	15	183.2	⅓ thread	−4.7	333.1
	17	06	186.2	1½ "	−3.6	339.4
	17	19	186.1	⅓ "	−1.5	347.4
	17	30	186	0 "	−1.0	351.4

and for

PROJECTION DECEMBER 8, 1900.

TABLE II.

Date	h.	m.	P. A. °	d.	Lat. °	Long. °
Dec. 8	15	50	186.3	½ thread	−1.9	315.2
	16	25	188.1	1½ "	−1.4	319.5
	16	44	187.1	½ "	−0.8	328.5

15. The numerical value of d was got as follows: Mr. Douglass' micrometric measures of the spider's thread were obtained by moving the movable thread from contact on the one side of the stationary thread to contact on the other. This gave 0″.22 for the width of a thread.

In the estimating of the distance d the thread was placed against the background of the disk. As a measure of width it was therefore its true width less the irradiation into it from both sides. The value of this irradiation was determined by the following device which occurred to me, and which if accurately made should give the irradiation absolutely. From the point of

PLATE X.

I. $15^h\ 39^m$ II. $16^h\ 15^m$ III. $16^h\ 22^m$ IV. $16^h\ 30^m$ V. $16^h\ 37\frac{1}{2}^m$

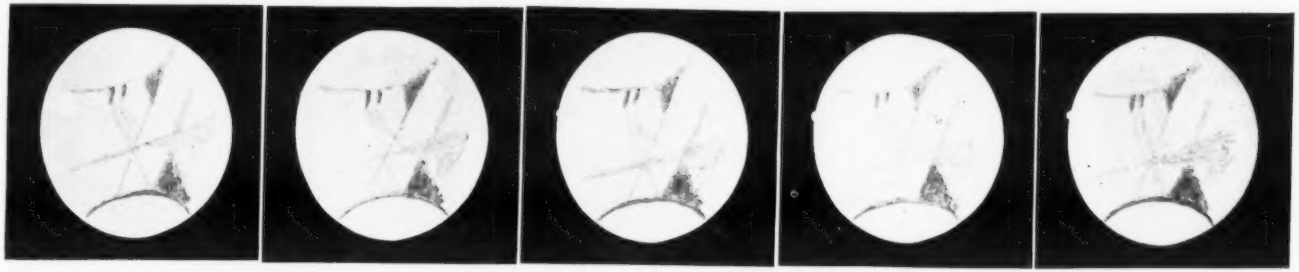
VI. $16^h\ 51^m$ VII. $17^h\ 6^m$ VIII. $17^h\ 19^m$ IX. $17^h\ 22^m$ X. $17^h\ 30^m$

MARS. THE PROJECTION OF DEC. 7, 1900

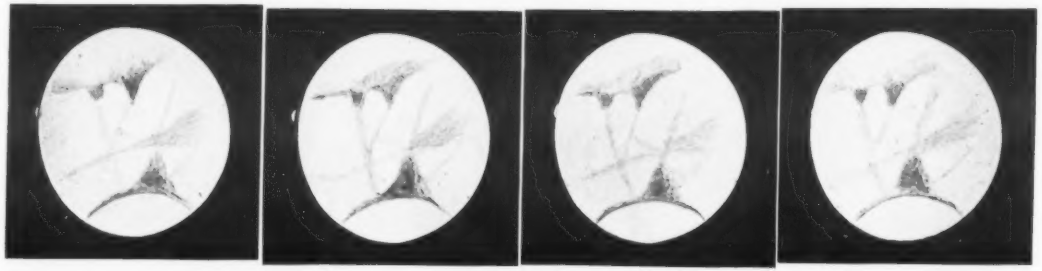
AT INTERVALS OF A FEW MINUTES DURING THE TIME OF ITS APPEARANCE.

OBSERVED AT LOWELL OBSERVATORY, FLAGSTAFF, ARIZONA.

PLATE XI.



I. $15^h\ 40^m$ II. $15^h\ 44^m$ III. $15^h\ 48^m$ IV. $15^h\ 58^m$ V. $16^h\ 2\frac{1}{2}^m$



VI. $16^h\ 20^m$ VII. $16^h\ 25^m$ VIII. $16^h\ 44^m$ IX. $16^h\ 50^m$

MARS. THE PROJECTION OF DEC. 8, 1900

AT INTERVALS OF A FEW MINUTES DURING THE TIME OF ITS APPEARANCE.

OBSERVED AT LOWELL OBSERVATORY, FLAGSTAFF, ARIZONA.

contact the thread is moved till the bright background seems equal to the width of the thread. We then have the following equation, in which

a = width of thread.

b = width moved from contact to one apparent thread apart.

x = the irradiation.

$a - 2x = b + 2x$.

or

$$x = \frac{a-b}{4}$$

b proved $= 0''.14$

whence the effective width of the thread was $0''.18$.

The P. A.'s used were got either directly or by plotting all the P. A.'s taken and then drawing the centre of gravity line between them.

16. The first thing that appears from the tables is that the observations cannot be satisfied by the supposition of one cloud alone on either day. It is necessary to suppose two on each occasion, a high cloud followed by a much lower one. The height of the lower cloud was about three to four miles, and it lay to the west and north of the main one.

The eastward end of the main cloud on December 7 was in latitude $4°.7$, longitude $333°$; its westward end in latitude $3°.6$, longitude $339°$. So that the cloud either stretched this distance or moved over it in the interval. From the great speed required it is unlikely that the cloud actually travelled this distance in this time. If translation took place at all, it was probably the translation of propagation. But, from the phenomena of the next night, it would seem more likely that the cloud really stretched over $6°$ or 220 miles. Its breadth was ½ thread or $0''.09$, which is forty-five miles.

The dimensions of the subsidiary cloud, or subsidiary portion of the main cloud, are much more conjectural. It would seem to have been of about the same extent as the main body.

On December 8 the main cloud was slightly less long but broader than it had been on the preceding night; the subsidiary patch was not much changed. But both clouds had in the interval drifted $17°$ to the eastward and $3°$ or so to the north. Whether, therefore, the clouds were being propagated or not in a west-by-north direction each night, it would seem that either they or the stratum of air which generated them was drifting east by north at the rate of $17° +$ in twenty-three and a half hours, or at the rate of twenty-seven miles an hour.

17. Looking back now, with this motion in mind, in the records of the 12th December; § 11, we find that the place the clouds should have occupied on that date (longitude centre 302° — 317°), if the same translation had been kept up, was under careful observation for such phenomena and nothing whatever was seen. Indeed, so comprehensive in extent were the observations, that any less speed of translation should also have caused the clouds to fall within the limits of inspection, and even a somewhat greater speed should have done so too.

On the 13th the place they should have reached was scrutinized. The observations covered from longitude centre 280° to 208°. Nothing showed. The same was done on the 15th, longitude centre 276° — 285°.

We may conclude, I think, that the cloud formation had dissipated at some time between the 8th and the 12th.

18. The season of the martian year at which these clouds occurred is of interest. On December 7, 1901, it was April 26 in the northern hemisphere of Mars. The Sun had gone north of the equator and was then overhead on the fourteenth parallel of latitude. The heat equator was a little behind it. Apparently then a current bearing the clouds was setting toward the heat equator from within the tropics to the south, where the season corresponded to the end of October. This current was deflected some eighty degrees to the east, and became an east-by-north wind.

19. Its origin may have been local. A little to the south of where the cloud first appeared lies the long east-and-west stretch of the Sabæus Sinus or Icarium Mare. Now the form of the cloud was of the same general shape—a cloud stretching east and west five times as far as it did north and south. The Icarium Mare is undoubtedly a great tract of vegetation, where moisture would be held and whence it could accordingly be given off. Arising there, either from seasonal or temporal cause, the vapor would gather into a cloud and proceed to float away over the desert regions to the north. If this, then, is what happened in the case before us, we may conceive the cloud as having been generated on the 6th of December over the Icarium Mare, rising to a height of thirteen miles, and then traveling east by north at about twenty-seven miles an hour off into the desert of Aeria, there to dissipate after an existence of three or four days. That it was a phenomenon of capricious not of regular production is shown by its not having been repeated—that is, it partook of the subtle unpredictability of cloud.

EARLY OBSERVATIONS OF ALGOL STARS.

EDWARD C. PICKERING.

One of the most important uses of the collection of photographs at Cambridge is to determine early dates of minima of stars of the Algol type. Nearly all of the early photographs were taken with the 8-inch Draper telescope. The number has been greatly increased during the last three years by supplementing its work with anastigmat lenses. In the *Astron. Nach.* 156, 313, Mr. Williams announces that the star 78.1901, R. A. = $20^h\ 18^m\ 4^s.0$, Decl. = $+42°\ 46'.4$ (1855), is a star of the Algol type. One hundred and seventy-seven photographs of this region were contained in the Harvard collection, the first being on September 19, 1885. On ten of these the star was distinctly fainter than its normal brightness. Measures with the 12-inch Meridian Photometer gave the maximum magnitude of this star 10.47. Assuming this value, a light curve, whose coördinates are given in Table I, was determined by Professor Wendell from observations with the 15-inch telescope.

TABLE I.—LIGHT CURVE.

Ph.	Dec.	Inc.	Ph.	Dec.	Inc.
d			d		
0.20	10.47	10.47	0.08	11.45	11.38
0.18	10.55	10.50	0.06	11.80	11.75
0.16	10.67	10.57	0.04	12.22	12.16
0.14	10.81	10.75	0.02	12.76	12.64
0.12	11.07	11.03	0.00	13.05	13.05
0.10	11.15	11.11			

The various determinations of the minima are enumerated in Table II. The year, month and day are given in the first column, the Greenwich Mean Time in the second, the Julian Day and fraction in the third, and the photographic magnitude in the fourth. The fifth column gives the time from minimum, indicated by the magnitude according to the light curve, assuming that the normal photographic magnitude is 10.2. On three of the plates the star was not seen, although stars of the magnitude 11.7 were visible. This indicates that the star was within $0^d.06$ of minimum. The last four lines relate to visual observations, three by Mr. Williams and the last one by Professor Wendell. The letter *m* is entered in the fourth column, and the value in the fifth is of course zero. The adopted formula for the times of minima is 2,410,000.20 + 3.45083 E, which agrees closely with that given by Mr. Williams. The value of E is given in the sixth column, and the deviation O—C in the seventh. These deviations

must be corrected by the values in the fifth column, although they are sometimes thus increased. In the first line the correction may have any value from $+ 0^d.06$ to $- 0^d.06$, but even the latter leaves the deviation $+ 0^d.009$. In the second line the magnitude 10.83 shows that the time of minimum must have preceded or followed the time of observation by $0^d.121$.

It is by no means certain that the best value of the period, $3^d.45083 = 3^d\ 10^h\ 47^m\ 12^s$, has been found. A change of one or two seconds would, however, increase the residuals perceptibly. It is curious, and perhaps suspicious, that the correction has always been taken with the negative sign, that is, that the star when photographed was in each of the ten cases increasing in light. One result, that on J. D. 4193, seems entirely wrong. The minimum apparently took place half a day too late. Some of the large residuals occur when the star is bright, or when it is changing slowly. We should expect that they would be the most uncertain. It is probable that more accurate results can be obtained when the photographic light curve is better known, and also by correcting for aberration.

TABLE II.—OBSERVED MINIMA OF 78.1901.

Y.	M.	D.	G. M. T. h	m	J. D. d	Magn.	Curve. d	E.	Unc. d	Corr. d
1890	5	16	19	56	1504.831	< 11.7	± .06	436	+ .069	+ .009
1891	1	13	10	50	1746.451	10.83	— .121	506	+ .131	+ .010
1892	9	18	14	07	2360.588	< 11.7	± .06	684	+ .020	.000
1893	7	29	18	04	2674.753	10.67	— .143	775	+ .160	+ .017
1894	9	23	14	03	3095.585	< 11.3	± .08	897	— .010	.000
1895	8	10	14	52	3416.619	10.98	— .107	990	+ .097	— .010
1896	8	20	16	32	3792.689	< 11.7	± .06	1099	+ .027	.000
1897	9	25	14	46	4193.615	10.86	— .120	1215	+ .657	+ .537
1898	1	13	10	43	4303.447	11.62	— .062	1247	+ .062	.000
1899	10	3	13	43	4931.572	10.52	— .162	1429	+ .136	— .026
1901	8	24	14	27	5621.602	m	.00	1629	.000	.000
"	9	7	9	43	5635.405	m	.00	1633	.000	.000
"	"	14	7	29	5642.312	m	.00	1635	+ .005	+ .005
"	11	1	14	47	5690.617	m	.00	1649	— .002	— .002

In *Astron. Nach.* 157, 79, Dr. Schwab announced that the star + 19° 3975, 93.1901, R. A. = $19^h\ 14^m\ 26^s$, Decl. = 19° 25′.4 (1900), was a variable of the Algol type. From the *Harvard Annals*, Vols. XXIV and XLV, it appears that the photometric magnitude of this star when at full brightness is 6.50, the range in the measures on four nights being less than a tenth of a magnitude. An examination of the Harvard photographs showed that we had 155 images in which its brightness was nearly normal, and 13 in which it was near minimum. For the obser-

vations near minimum, Table III gives in successive columns the year, month and day, the Greenwich Mean Time, the Julian Day and fraction, the approximate magnitude, the assumed value of E, and the uncorrected residual found by subtracting the time computed by the formula, 2,410,011.6 + 17 E.

TABLE III.—OBSERVED MINIMA OF 93.1901.

Y. M. D.			G. M. T.		J. D.	Magn.	E.	Unc.
			h	m	d			d
1887	8	3	15	35	0487.649	7.06	28	+ 0.05
1890	11	5	10	48	1677.450	9.15	98	— 0.15
1891	7	13	16	28	1927.686	8.68	113	— 4.91
1893	8	4	15	2	2680.626	7.06	157	+ 0.03
"	"	"	15	14	2680.635	7.06	"	+ 0.04
1894	10	15	12	8	3117.506	7.35	183	— 5.09
1895	8	22	13	22	3428.557	8.74	201	— 0.04
"	"	"	14	25	3428.601	8.11	"	0.00
"	9	8	14	22	3445.599	8.40	202	0.00
1897	9	24	13	31	4192.563	7.06	246	— 1.04
1900	5	22	19	33	5162.815	7.80	303	+ 0.22
1901	5	12	19	4	5517.794	8.74	324	— 1.81
"	7	12	17	13	5578.713	9.15	327	+ 8.11
"	"	"	17	28	5578.728	9.11	"	+ 8.13
"	10	8	13	14	5666.551	8.68	333	— 6.05
"	11	1	6	30	5690.27	m	334	+ 0.67
"	"	28	12		5717.50	m?	336	— 6.10
1902	1	4	12		5754.5	m?	338	— 3.10

The photograph on J. D. 3428 is especially valuable. The spectrum, which is of the first type like other Algol stars, trailed over the plate, and showed that the star was at first of about the ninth magnitude, after about half an hour suddenly becoming brighter until it attained the eighth magnitude at the end of the exposure. Two lines have, therefore, been given to this plate. When the law of variation becomes known this will probably give an accurate value of the time of minimum. The last line but two represents the observation of Dr. Schwab, the last line but one that Professor Wendell. On this last date, the star had apparently nearly recovered its full brightness, the range of the observations not exceeding two tenths of a magnitude. The last line represents a somewhat uncertain observation by Mr. White when the star was near the horizon. The range in light appears to be greater than that of any other Algol star. The period, 17 days, given by Dr. Schwab, is longer than that of any other Algol variable, and does not satisfy the observations. No subdivision, or other value of the period, appears to give better results. By a slight change in the period, and by applying a correction for the light curve and for aberrration, about half of the residuals in the last column of Table III could be reduced nearly

to zero. The others are so large, amounting to several days, that their careful study becomes a matter of very great importance. If these discordances are due to a third body this star will become one of the most interesting in the sky. Evidently it should be carefully watched. This has been done at Cambridge ever since its variability was announced. On two dates, November 18 and December 22, 1901, when minima were expected, according to the formula of Dr. Schwab, clouds prevented observations, and on a third day, December 5, 1901, no diminution in light was perceptible. During the coming year it is proposed to look at it early and late on each clear evening at Cambridge and Arequipa. The value of this work would be greatly increased if observers in other longitudes would coöperate. A continuous watch might thus be kept upon it, and no minima missed. The observations needed are very simple. The star when at full brightness is easily seen with an opera-glass, and it is only necessary to select two adjacent stars, one a little brighter, the other a little fainter, as + 19°3956 and + 18°4043, and see each night if the brightness is normal. Any observations when the star is faint will be very valuable. If the observer is not accustomed to the method of Argelander, it will only be necessary to name one or two stars which are a little brighter and others a little fainter at a given hour and minute. These observations should be repeated two or three times an hour to detect changes. The stars may be identified by a sketch of the region, if desired. The value will be greatly increased if any kind of photograph can be taken, attaching a hand camera to an equatorial or even allowing the stars to trail through the field. The detailed observations should be forwarded at once by mail, and if possible the time of minimum cabled. For instance, "Observatory, Boston, Schwab twenty-first sixteen, Smith," would be understood to mean that Mr. Smith found Schwab's variable at minimum on the twenty-first of the current, or preceding, month at sixteen hours after Greenwich Mean Noon. The message sent from here, "Schwab, May twenty-first," would indicate that a minimum was predicted for that date, and that observations on that evening were greatly desired. It is hoped that by aid of astronomers in Asia and Australia it will be possible to follow the star continuously during the present year, so that no minima will be missed, or if only during a limited period, as the month of July, 1902, when the star is in opposition to the Sun.

HARVARD COLLEGE OBSERVATORY, *Circular* No. 64,
January 18, 1902.

THE LIGHT CURVE OF THE NEW STAR IN PERSEUS.

CONTINUED FROM PAGE 96.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude.		Color
				Obs'r.	Revised.	
May	h					
24	10.3	Bohlin	(71) 5 N 1 (83)	6.35	6.18	
	12.6	Epstein	$I = > (71) > (72) >> (81) >> N = (83)$		6.34	
	13.6	Epstein	$N > (83); I > (71)$		> 6.3	
	13.8	Epstein	$N < = (83)$		6.3:	
25	11.2	Bohlin	(71) 2 N 5 (83); N = (72)	5.76	5.55	
26	9.7	Bohlin	*I* 4 N 2 (72); (71) = N	5.52	5.29	
	13.4	Epstein	$(71) = I > (72) >> (81) > N >> (83)$		6.2	*
27	9.6	Plassmann		6.35		
	11.0	Bohlin	(71) 4 N 5 (83); (72) 4 N	6.01	5.78	
28	13.5	Epstein	$I > (71) > (72) >> (81) > N >> (83)$		6.2	
	23.5	Aitken		6.05		
June						
1	10.4	Bohlin	(71) 5 N 2 (83); (72) 3 N	6.15	5.93	
	23	Aitken		6.25		
2	22.8	Aitken		6.12		
3	11.0	Robinson	*I* (72)	5.05	5.15	
	11.3	Bohlin	(72) 3 N 0 (71)	5.55	5.35	
	23	Aitken		4.95		
4	10.0	Plassmann		6.12		
	23	Aitken		5.90		
5	10.5	Plassmann		6.09		
	14.4	Müller A	(85) (83)	6.5		R
	23.5	Aitken		6.0		
6	10.5	Robinson	(83) (79)	6.00	6.17	*
	13.8	Williams	(71) 8.7 N 5.7 (83)	6.10	5.94	
	13.9	Müller A	(85) (83)	6.5		R
	22	Aitken		6.25		
7	11.2	Plassmann		6.10		
	19	Fauth		6.50		
	22	Aitken		5.8		
8	11.0	Robinson	(72), *l*. ν, κ	4.57	4.61	R†
	12.5	Ambronn	$N = I$ or at most $0.1 > I$; (72) 2 *I* 1 N	5.00	4.92	
	13.3	Meyermann	ν, *I*	4.7		
	13.8	Williams	N 1 (71); N 15 (83)	5.3	5.28	
	22	Aitken		6.10		
	22.6	Fauth		5.75		
9	10.5	Plassmann		6.70		
	18.2	Fauth		6.00		
10	10.5	Bohlin	(71) 5 N 2 (83)	6.24	6.06	
	12.4	Meyermann	(71) (83)	5.8		
	14.0	Müller A	(85), (72)	6.0		
	14.3	Williams	(71) 12.5 N 2 (83)	6.45	6.20	
13	12 5	Fauth		6.05		
	14.4	Fauth		5.96		
	22	Aitken		5.75		
14	22	Aitken		5.66		
17	10.7	Robinson	(72), (79)	5.80		VR
	13.8	Müller A	(85) (83)	6.5		PR
18	10.8	Robinson	(72) (83) (79)	5.99		
	23	Aitken		6.0		

* Not very red. † κ red

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude.		Color
				Obs'r.	Revised.	
June	h					
19	10.5	Plassmann		6.05		
	14.6	Fauth		5.90		
20	13.8	Müller A	(85)	6.4		R
	14.2	Fauth		5.92		
		Solá		5.2		
	23.2	Aitken		6.2		
21		Solá		5.3		
	10.8	Bohlin	(71) 1 N 5 (83)	5.71	5.51	
	13.7	Fauth		6.00		
	14.0	Müller	(85)	6.4		R
	14.4	Fauth		5.89		
	23.2	Aitken		6.0		
22	11.3	Bohlin	*l* 2 N 2 (71)	5.32	5.20	
	12.0	Müller A	ψ	4.5		Y
	14.2	Fauth		5.78		
	14.8	Fauth		5.81		
	21.1	Aitken		5.2		
23		Solá		5.3		
	10.9	Bohlin	(71) 5 N 1 (83)	6.35	6.18	
	12.5	Müller A	(85), (83)	6.2		R
24	11.5	Bohlin	(71) 1 N 3 (83)	5.79	5.59	
	13.2	Fauth		5.72		
	13.5	Müller A	*l*, (72)	5.2		W
	23	Aitken		5.8		
26	21	Aitken		6.10		
27	12.0	Muller A	(72), (85), (83)	6.0		
	13.7	Fauth		5.85		
	21.2	Aitken		6.10		
28	10.7	Bohlin	(71) 4 N 3 (83)	6.10	5.92	
	12.0	Muller A	(72), (85), (83)	6.1		Y
	14.2	Fauth		5.90		
	21.5	Aitken		6.05		
29	10.1	Bohlin	(71) 4 N 1 (83)	6.32	6.14	Y
	12.0	Muller A	(72), (85), (83)	6.2		DR
	21.0	Aitken		6.25		
30	12.2	Muller A	(85), (83)	6.2		R
July						
1	10.9	Bohlin	(71) 6 N 1 (83)	6.37	6.20	
	11.1	Robinson	(72)	5.90		*
	12.0	Muller A	(85), (83)	6.4		R
	22	Aitken		6.25		

* No marked color.

The fluctuations in the light of the star having practically ceased in June, it seems unnecessary to continue the publication of the chronological list of observations further. In the second chart of the Light Curve the observations have been platted up to July 13, and it will be seen that those during July may be represented closely by a straight, slightly descending, line. Observations are in hand extending to Feb. 1902, but there are no further indications of any great fluctuations. The star up to this time has declined to between 7.5 and 8.0 magnitude.

Supplementary List of Observations.

The following lists of observations were received during the course of the publication of this paper, and the later portions of each were inserted in the chronological list. The omitted portions are here appended.

Townley, S. D., Berkeley, Cal. P. A. S. P. 79. An excellent series extending from Feb. 24 to May 12. The observations were made with the naked eye to Mar. 14 and after that with field-glasses, or with a 15.4 centimeter Clark equatorial and its 4.5 centimeter finder. Two methods, that by steps and that by proportional brightness were employed. According to the notation used, α 3 δ signifies that the nova was three-tenths of the way from α to δ Persei in the scale of brightness, and 4 δ that the nova was four steps brighter than δ.

Date 1901.	Gr. M. T.	Comparisons.	Magnitude.	
			Obs'r.	Revised
Feb.	h			
24	16.5	N = < β Orionis; α Aur. 5 β Gem.; α Aur. 2-3 α Urs. Min.	0.6	0.72
25	16.5	β Orion. 3 α Urs. Min.; α Aur. 8-9 β Gem.; N = β Gem.; β Orion. 6-5 α Tauri; α Can. Min. 6 α Tauri.	1.0	0.94
26	18.5	α Tauri 3-4 α Urs. Min.; β Orion. 8 α Urs. Min.; β Gem. 5 α Urs. Min.; β Gem. 4 α Gem.	1.7	1.58
27	15.1	α Tauri 8-9 α Urs. Min.; N = α Pers.; α Tauri 7 γ Androm.; β Androm. 4 γ Androm.	2.0	2.00
Mar.				
1	15.6	α Pers. 7-8 β Pers.	2.2	2.27
2	15.6	α 4 β; α, β Androm. 1 γ Androm. N 2 β; α Urs. Min. 2 N	2.1	2.20
3	16.0	β 3 ε; β 1-2 δ; α 2 β Androm. α Urs. Min. 1 γ Androm. 2 β 2 N	2.5	2.61
4	15.6	α 3 δ; α 3 ε; 4 δ Cass.	2.3	2.28
5	15.6	N β, γ Cass.; β Cass. 1 N; α Urs. Min. 1-2 N	2.3	2.38
6	15.6	N 3 ρ; β 7 ρ	3.1	3.3
8	15.0	β 4 ρ	2.7	2.9
10	18.0	β 3-4 ρ; δ Cass. 2 N; β 7-8 ε; β 7 δ	2.8	2.88
11	16.5	β 9 ρ; N 1 ρ; δ 1 N; ε 2-3 N; ε 4 κ	3.2	3.25
12	18.0	ε N 2 δ; ε 1 κ; γ 1-2 N; β 6 ρ	3.0	3.06
13	17	ε 4 κ; δ 5—6 κ; ε 5 ν; δ 6—7 ν	3.5	3.51
14	17 0	δ 1 N; ε 2 ν; γ 1 N; β 7 ρ; ζ N	3.1	3.14
15	18.5	κ 2 ν 1 N	4.1	4.16
17	17.0	δ 7 ν; δ 5 κ; ε 7 ν; ε 5 κ	3.6	3.58
22	17.8	N ι; κ 3 *l*; ν 2-3 N	4.2	4.22

Aitken, R. G., Lick Observatory. *Bull. Lick. Obs. No. 8.* An excellent series extending from Feb. 24 to July 27. The details of the comparisons are not given, but the observations were at first made without instrumental aid by comparing the star with Capella, α, ε, δ, ν, χ Persei. As the star's light faded, opera glasses, and later the 3-inch finder of the 12-inch telescope, were used, comparisons being made with the stars ψ, σ, *l* Persei and with BD + 43°.674, BD + 45°.778 and BD + 44°.734; the magnitudes being taken from Hagen's Chart I.

Date.	Gr. M. T.	Mag.	Date.	Gr. M. T.	Mag.
	h			h	
Feb. 24	16	0.5	Mar. 8	15	3.2
25	9	1.0	12	17	3.5
25	14.5	0.9	13	17	3.7
26	15.5	1.4	14	15—18	3.5
27	15	2.0	15	16	3.8
28	18	2.0	16	16	3.9
Mar. 1	16	2.4	17	16—18	3.9
2	15	2.4	18	16	4.0
3	15	2.5	19	15—17	4.1
4	16.3	2.5	20	15.5	4.5
5	15—18	2.7	22	16	4.7
6	15—18	3.0			

Jones, G. L., Medford, Mass. P. A. 90. The observations after April 1 were made with a field glass magnifying four and a half times. The magnitudes of the comparison stars were taken from the list in this paper.

Feb. 25	12.0	1.00	Feb. 28	14.0	2.05
26	14.0	1.34	Mar. 1	16.0	2.40
27	14.5	2.16			

Whitney, Professor Mary E. and Miss Furness, Vassar College Observatory. P. A. 90. The observations extend from Feb. 21 to May 7 and the comparisons are given in detail.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude.		Color
				Obs'r.	Revised	
Feb.	h					
21	16.0	A student	Nearly as bright as Capella	0.6		
25	...	Whitney	= Pollux	1.3	1.21	
25	13.5	Furness	= Pollux	1.3	1.21	
26	15.0	Whitney, Furness	Pollux N Castor	1.45	1.40	
27	15.0	Whitney	= α	1.9	1.88	
28	12.0	Furness	Bellatrix N α	1.9	1.78	
28	15.0	Whitney	N 2 α	1.7	1.68	
May						
2	14.0	Furness	N = β	2.3	2.4	
2	14.5	Whitney	α 2 N 2 β	2.1	2.1	
5	15.5	Whitney	β 2 N 3 ϵ; N = ι Aurigæ	2.6	2.75	*
6	13.0	Whitney	N 2 δ; N 1 γ	2.9	2.94	
12	16.5	Whitney	δ 2 N 4 ν	3.4	3.38	
16	12.5	Furness	κ 2 N 2 ι; ν 1 N	4.1	4.06	
	13.8	Furness	κ 1 N; ν 2 N 1 ι	4.1	4.11	
	14.5	Whitney	N = ν; N 2 κ	3.9	3.86	
	15.6	Whitney	N 1 ν; N 2 κ	3.8	3.82	
17	14.2	Furness	δ 3 N 2 ν; N 2 η	3.6	3.65	
	14-15	Whitney	N 2 ν; N 2 κ; N 2 η	3.7	3.75	
18	12.2	Whitney	N 1 ν; N 1 η	3.8	3.83	
	14.8	Whitney	N = ν; N 1 η	3.9	3.88	
19	14.0	Furness	N 1 *l*	5.0	4.93	
21	13.0	Whitney	N = ξ	4.1	4.05	
	13.0	Furness	ι 1 N; N 2 *l*	4.5	4.56	
	14.5	Furness	ι 3 N 1 *l*	4.8	4.82	
	16.0	Whitney	ψ 1 N 2 *l*; ψ N (71)	4.6	4.66	
22	13.5	Whitney	ν N *l*	4.5	4.48	
	14.8	Furness	N = τ; N 1 ψ	4.1	4.11	

* Redder than on previous nights.

Schwab, Fr., Kremsmünster. *A. N.* 3746. These observations extend from March 14 to May 22 and from Aug. 1 to 22, and were made with the aid of a field glass. The comparisons are given and have been reduced by the writer.

Date.	G.M.T. h	Comparisons.	Mag.	Date.	G.M.T. h	Comparisons.	Mag.
Mar. 14	7	δ 1 N 4 ν	3.27	Mar. 30	9	ν 2 N = κ, N 3 ψ	4.00
15	7	δ 2 N 3 ν	3.43		11	ν 2 N = κ, N 3 ψ	4.00
17	7.5	δ 3 N 2 ν	3.60	31	7	ν 2 N 1 κ, N 3 ψ	3.98
18	7	δ 3 N 2 ν	3.60	Apr. 1	7	ν 2 N 1 κ	3.98
24	8	ν => N 2 ψ	3.93	2	8	ψ 2 N 2 *l*	4.74
25	8	*l* 2 N 1 (71)	5.24	11	7	(71) 1 N => (72) *l* 4 N	5.37
29	8	ψ 1 N 3 *l*	4.45	11	9	(71) 1 N = (72)	5.37
30	7	ν 1 N 1 κ	3.96				

Gore, J. E., Ballysodare, Ireland. *M. N.* LXII, 156. Naked eye and binocular, Feb. 22 to Nov. 16, 1901. Reduced to Harvard System.

Date 1901.	Gr. M. T.	Comparisons.	Magnitude. Obs'r.	Revised	Color
Feb.	h				
22	11.7	Much > α Pers.; : = Pollux	1.25	1.2	
23	11.4	Through clouds; seems at least 1^m.			
24	10.8	= Capella	0.24	0.22	YW
26	10.9	1^m < Capella; 1^m > α Persei	1.05	1.05	
27	11.8	N 1 α Pers.; N 4 β	1.73	1.84	*
Mar.					
1	7.7	α 1 N; not much > β	2.0	2.00	
	10.6	α 2 N	2.13	2.12	
2	9.2	About same brightness			
	10.1	α 1½ N 1½ β	2.08	2.14	†
3	8.5	α 3½ N; β 1 N	2.45	2.40	O
7	7.1	N : = ϵ	2.88	2.9	
	9.6	N = ϵ; N 2½ δ	2.82	2.86	
8	11.6	ϵ 2 N = δ	3.11	3.14	
12	10.2	δ 2 N 6 ν	3.31	3:31	
13	10.3	A little fainter; in clouds			
18	11.0	: = ν; < δ	3.90	3.9	
21	8.9	ν 1 N; N > *l*	4.0	4.05	R‡
23	8.2	N 1 κ; N 2 κ	3.85	3.82	
25	12.1	*l* 2 N; 3 (72)	5.22	5.17	
26	8.7	ν 1 N; much > *l*	4.05	4.05	
	10.9	ν 2 N	4.18	4.17	
27	8.9	N much > *l*; : = ν; N 1 κ	3.90	3.92	
28	9.1	N = *l*; N 3 (71)	5.13	5.01	
29	10.4	N < ν; N 3 *l*	4.73	4.67	
Apr.					
1	9.1	ν 3 N 5 *l*	4.35	4.34	
6	9.2	*l* 4 N 1 (72)	5.32	5.27	
7	8.7	N = (72); < *l*	5.37	5.37	
	9.8	(72) 1 N. Just visible to naked eye	5.50	5.49	
8	10.0		4.5±		
	10.4		4.5±		
9	8.8	ν 4 N 3 *l*; ν 4 N 4 (71)	4.59	4.60	
	9.8	ν 4 N 2 *l*; ν 4 N 5 (71)	4.61	4.56	
11	11.8	N = (72); < *l*	5.37	5.37	
13	9.2	ν 2 N 5 *l*	4.25	4.24	
14	10.2	N = (72) or (72) 1 N	5.44	5.43	
15	10.2	N = (72)	5.37	5.37	
16	9.0	(72) 1 N; < *l*	5.50	5.49	

* Same color as Capella: † More yellowish than α. ‡ Claret tint.

Date 1901.	Gr. M. T.	Comparisons.	Magnitude. Obs'r.	Revised	Color
Apr.	h				
16	9.8	N : = (72)	5.37	5.4	
18	9.3	ν 4 N 6 *l*	4.39	4.37	
19	8.9	*l* 5 N 1 (72)	5.33	5.31	
20	9.1	(72) 1 N	5.50	5.49	
21	10.0	N : = (72). Hazy.	5.37?	5.4	
27	9.2	ν 4 N 4½ *l*	4.48	4.45	
28	9.8	N : = (72) or N 1 (72)	5.30	5.31	
30	9.6	N : = (72)	5.37	5.4	
May					
1	9.6		4.5?		
	10.3	$\nu > N > l$	4.56		
5	1.4	(72) 1 N	5.50	5.49	
6	10.6		5.5?		

Bohlin, K., Stockholm. *A. N.* 3762. A fine series extending from Feb. 25 to Aug. 16. The details of the comparisons are given and the reductions are to the Potsdam system. Value of 1 step = 0.10.

Feb.	h			
25	10.0	N 4 α	1.4	1.48
Mar				
6	6.0	γ Androm. 1 N 4 δ	2.38	2.40
	6.3	β 3 N	3.03	2.7
	6.6	γ Androm. 4 N 4 δ; β 3 N	2.74	2.67
11	12.5	δ 4 N 2 ν	3.79	3.65
12	9.3	δ 2 N 4 ν	3.56	3.38
13	9.3	δ 2 N 4 ν	3.56	3.38
18	7.7	δ 1 N 4 ν	3.46	3.27
19	9.4	*l* 1 N 4 (72)	5.21	5.10
	10.6	N = *l*	5.10	5.03
20	6.9	δ 3 N 2 κ	3.73	3.64
	7.1	δ 4 N 2 ν	3.80	3.70
	7.3	δ 3 N 3 ν	3.68	3.55
	10.0	δ 2 N 4 ν	3.56	3.40
21	6.9	δ 3 N 3 ν	3.68	3.55
	9.9	ν 0 N 3 σ	4.03	4.09
	10.5	ν 2 N 3 σ	4.22	4.18
	15.5	ν 2 N	4.22	4.13
22	7.7	*l* 1 N 5 (72)	5.19	5.09
	9.1	*l* 1 N 4 (72)	5.21	5.10
	15.5	ν 2 N 2 σ	4.27	4.24
23	7.3	δ 5 N 1 ν	3.91	3.79
	7.7	δ 3 N 4 ν	3.62	3.46
	8.0	δ 4 N 3 ν	3.72	3.57
	15.6	δ 4 N 4 ν	3.68	3.52
25	7.2	*l* 4 N 3 (72)	5.42	5.22
	8.3	*l* 2 N 4 (72)	5.28	5.14
26	6.9	ν 4 N 2 ψ	4.45	4.15
	9.4	δ 5 N 0 ν	4.03	3.72
	11.0	δ 5 N 1 ν	3.91	3.79
27	8.7	δ 4 N 3 ν	3.73	3.57
	10.0	δ 5 N 1 ν	3.91	3.79
28	7.2	σ 4 N 1 *l*	4.98	4.93
	8.0	σ 3 N 2 *l*	4.86	4.83
	9.1	σ 4 N 2 *l*	4.90	4.87
	10.7	ν 4 N 4 *l*	4.57	4.48

Date 1901.	Gr. M. T.	Comparisons.	Magnitude. Obs'r.	Magnitude. Revised.	Color
Apr.					
1	11.9	ν 2 N 4 ψ	4.24	4.04	
2	7.5	*l* 1 N 4 (72)	5.21	5.10	
	9.4	*l* 2 N 3 (72)	5.32	5.17	
	11.0	*l* 2 N 4 (72)	5.28	5.14	
5	6.8	ν 4 N 2 σ	4.35	4.34	
	8.0	ν 5 N 0 σ	4.51	4.49	
6	7.5	*l* 5 N 0 (72)	5.65	5.45	
	8.7	(72) 2 N 6 (83)	5.75	5.62	
	12.2	(72) 1 N 10 (83)	5.68	5.46	
7	7.3	(72) 3 N 6 (83)	5.78	5.70	
	8.7	(72) 1 N 1 (71)	5.60	5.36	
	12.2	*l* 6 N 2 (72)	5.51	5.28	
11	8.9	(72) = N	5.65	5.37	
	10.6	(72) 2 N 6 (83)	5.75	5.62	
14	8.7	*l* 4 N 2 (72)	5.47	5.26	
18	8.3	ν 2 N 3 σ	4.22	4.18	
	9.8	ν 2 N 4 σ	4.19	4.14	
22	10.2	N = (72)	5.65	5.37	
23	10.0	ν 1 N 3 σ	4.15	4.09	
23	10.6	ν 2 N 3 σ	4.22	4.18	

Hisgen, S. J., Valkenberg. *A. N.* 3762. Feb. 26 to Apr. 23, with naked eye. Reduced to the Harvard system. Value of 1 step 0.03.

Feb.					
26	7.4	β Gem. 8 N 6 α Gem.	1.46	1.43	
Mar.					
1	9.0	α 7 N 2 γ Cass. 3 β	2.13	2.14	
2	7.1	α Gem. 7 α 8 N 5 β	2.10	2.14	
3	9.0	α 10 N 3 γ Cass. 2 β	2.15	2.20	
5	9.0	β 4 N 8 δ Aur. 12 ϵ	2.47	2.44	
8	9.0	ϵ 4 δ 3 N 20 ν	3.22	3.22	
13	7.2	δ 18 N 8 ν	3.66	3.66	
21	8.3	δ 20 N 6 ν 8 κ	3.71	3.68	
24	7.5	δ 20 ρ 6 N 6 ν	3.78	3.84	
25	9.0	ν 6 κ; N invisible			
29	8.3	ν 8 ψ 10 σ 12 N	4.91	4.89	
Apr.					
4	8.6	ν 6 κ 6 N 5 σ	4.30	4.29	
7	8.4	σ 15 *l* 10 (71) 6 (72) 2 N 12 (83)	5.79	5.62	
18	9.0	ν 10 N 2 κ	4.07	3.99	
19	9.0	*l* 6 N 3 (71) 5 (72)	5.23	5.20	
20	9.0	N < (71)	< 5.27		
21	9.0	N invisible			
22	9.0	N invisible			
23	9.0	κ 5 N 3 σ	4.33	4.34	

Esch, M., S. J., Valkenberg. *A. N.* 3762. Feb. 26 to April 20, with opera glasses of 50 mm. aperture. Reduced to the Harvard System. Value of 1 step 0.03^m

Feb.	h				
26	7.8	α Aur. 20 N 7 α Pers.	1.28	1.44	
	8.5	α Aur. 30 N 5 α Pers.		1.64	
Mar.	9.0	α Aur. 30 N 7 α Pers.		1.57	
1	8.8	α 5 N 2 β	2.00	2.25	
	9.0	α 5 N 0 β		2.4	
	9.2	α 5 N — 1 β		2.5	

Date 1901.	Gr. M. T.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Mar.	h				
2	7.0	α 8 N 0 β	2.09	2.4	
3	9.0	α 8 β 1 N	2.12	2.46	
5	9.0	α 8 β 5 N	2.24	2.72	
8	6.5	N 1 γ 5 ϵ	2.85	3.18	
13	9.5	δ 20 N 5 ν	3.73	3.76	
21	7.5	δ 20 + N 5 ν	3.81	3.85	
24	8.5	ν 5 N 4 ι	4.07	4.07	
29	8.0	ψ 2 N 10 *l*	4.83	4.39	
Apr.					
2	9.0	*l* 3 N 10 (71)	5.13	5.10	
4	8.5	κ 10 N 10 σ	4.28	4.28	
7	7.5	(71) 6 (72) 3 N	5.45	5.37	
	9.3	(71) 5 (72) 2 N		5.38	
18	9.0	κ 5 ι 3 N	4.29	4.29	
19	7.8	*l* 15 N 4 (72)	5.33	5.29	
	9.0	(71) 3 N 4 (72)		5.36	
20	9.0	*l* 10 + (72) 1 N	5.41	5.40	
	9.5	(72) 0 N		5.37	

Merecki, B., Warschau. *A. N.* 3771. A series of measures with a wedge photometer and 14^{cm} Cooke refractor, the comparison stars being α, δ, ν, 30 Persei, and BD 44°734. The magnitudes of the comparison stars were those given by Müller and Kempf in *A. N.* 3714 and therefore were based upon the Potsdam system.

Feb.	h	m			
27	7.8	α — 0.13	2.04	1.75	W Y
Mar.					
3	7.4	α + 0.44	2.61	2.32	YR
7	6.6	α + 1.14	3.31	3.02	R
12	6.6	δ + 0.33	3.65	3.43	BP
13	8.7	δ + 0.94	4.26	4.04	BR
15	6.6	δ + 1.04	4.36	4.14	YR
17	7.0	δ + 0.76	4.08	3.86	BR
29	7.1				Y*
30	7.6	δ + 1.62	4.94	4.72	Y†
31	7.0	δ + 1.50	4.82	4.60	†
Apr.					
1	6.6	δ + 1.13	4.45	4.23	Y
5	9.2	δ + 1.60	4.92	4.70	YR
6	6.8	ν + 1.17	5.20	5.10	
	7.7	ν + 1.88; δ + 2.62	5.92	5.76	BR
	8.7	δ + 2.74	6.06	5.84	
7	7.4	ν + 2.39	6.41	6.32	BR
	8.4	ν + 1.76	5.79	5.69	
8	6.8	ν + 1.52	5.55	5.45	
11	7.9	ν + 2.00	6.03	5.93	YR
14	7.7	ν + 1.84	5.88	5.78	YR
18	8.4	ν + 0.23	4.26	4.16	YR
19	8.1	Invisible in clouds; ν visible			
22	7.6	ν + 1.62	5.65	5.55	Y
23	7.9	ν + 0.85	4.88	4.78	Y
24	7.7	ν + 1.37	5.40	5.30	YR
27	7.6	ν + 0.66	4.69	4.59	Y

* With red rays. † Somewhat reddish.

ECLIPSE AID TO CHRONOLOGY.

REV. Q. A. WHEAT.

No. 3.

FOR POPULAR ASTRONOMY.

Since my last paper on this subject, I have had occasion to examine more minutely into the comparative circumstances of the solar eclipse B. C. 730, March 14, that I have adopted as the eclipse recorded to have occurred at Nineveh, in the ninth year of Assur-danin-il II, King of Assyria; and, I think, that the results briefly stated will be of interest.

It is a matter of record that about the year B. C. 2317, "Yao [No-ah, who died 310 years later?] the first Emperor af China, determined the year to be 362.25 days;" which, according to my tables, was 18 years before Menes, first King of Egypt; and prior to Peleg "in whose days was Confusion of Tongues," 61 years; and it will not be far-fetched to conclude that that information respecting the year was generally known. But before that determination of the year's length the year was reckoned to be 360 days, which was retained by the Chaldean calendar, and in general use, with intercalary month every 6 years; and 5 days every year by the Egyptian, until at the era of the Exodus, Moses made the Hebrew calendar lunar, 354 days.

To determine the relation of the month Sivan, Chaldean time, the month in which the eclipse of "Assur-danin-il II" is recorded to have occurred, to the eclipse B. C. March 14, we

1. Having already determined Abib 14 (seventh Chaldean month) to have been co-incidental with the eclipse A. D. 29, November 24, we have the interval Julian time — 729.3.14 to A. D. 29.11.24, equal 758y, 8m, 10d = 278109 days;
2. Reduce to Chaldean time: 278109 ÷ 360 = 772y, 6m, 9d;
3. Take their difference

$$772.6.9 - 758.8.10 = 13y, 9m, 29d.$$

The 13 years having been cancelled by intercalarys, we find a gain by Chaldean time, of 9 months, and 29 days over full years, which were complete November 24.

4. Then (Nov. 24) 11.24 — 9.29 equals 1.25 (Jan. 25) which corresponds to Abib 14, in the year B. C. 730; and (Jan. 25) 1.25 — 0.14, equals 1.9 (Jan. 9) corresponds to Abib 1st, to which add 30 days of Abib we have Feb. 8; and the 30 days of

Jyar, we have March 10, equal Sivan 1; and 4 days to March 14, we have correspondingly Sivan 5th, which was the day of the eclipse in Nineveh B. C. 730.

A further result of this demonstration briefly stated in the rectification of my calculation for the day of the Exodus, which should be April 9, instead of April 3, without the prejudice of a presumptive inference drawn from the sacred text.

In conclusion, this result, I think, will be eminently satisfactory to my friend Professor Stockwell, in support of his theory of the value of eclipses to Chronology, and he is to be congratulated on his persistent holding of his position; and I am cordially grateful to him for his work in eclipse calculations, which is positively supporting and satisfactory to my researches in Biblical Chronology.

PORT REPUBLIC, Va.,
Feb. 19, 1902.

PLANET NOTES FOR APRIL.

H. C. WILSON.

Mercury is making the circuit of the farther side of his orbit from the Earth, and will be at superior conjunction April 28, so that he will not be visible to the naked eye during this month.

Venus is the brilliant morning star, seen toward the southeast before sunrise. She is just past her greatest brilliancy but will continue to be very conspicuous during the summer months. Venus will be at greatest elongation, 46° 11′ west from the Sun on April 25.

Mars, being just past superior conjunction, will be invisible during this month. The two planets Mercury and Mars will be within less than 1° from each other on April 23.

Jupiter and *Saturn* are morning stars together, seen toward the south just before sunrise. Both planets are conspicuous to the naked eye and are brighter than any of the neighboring stars. The Moon will pass Saturn on the morning of April 2, Jupiter, April 3, Venus, April 5, Saturn again April 29 and Jupiter on the morning of May 1. Saturn will be in quadrature 90° west from the Sun, April 18.

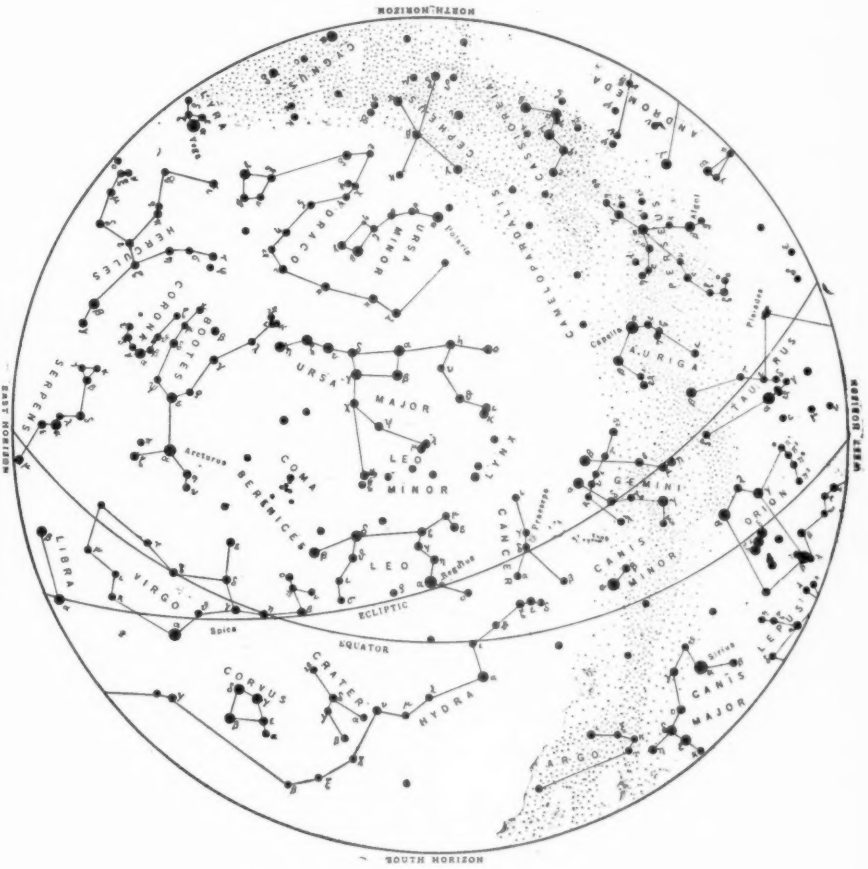
Uranus is near the meridian a couple of hours before sunrise, among the stars of Scorpio. A telescope is needed in order to find the planet.

Neptune is the evening planet but not visible except with the aid of a good telescope. Its position April 1 is: R. A. $5^h\ 54^m\ 51^s$; Decl. + 22° 18′. During the month it will move about $2^m\ 34^s$ eastward and 1½′ south.

A Partial Eclipse of the Sun will occur April 8, but it will be a very small one, only 0.065 of the Sun's diameter being obscured, and it will be visible only in the extreme northwestern part of North America and the northeastern corner of Siberia.

CIRCUMSTANCES OF THE ECLIPSE.

		Greenwich M. T.		Longitude fr'm Greenwich.		Latitude.	
		h	m	°	′	°	′
Eclipse begins.....	April 8	1	30.8	124	29 W	60	10 N
Greatest eclipse.....		2	05.2	142	38 W	71	47 N
Eclipse ends.....		2	39.1	175	31 E	81	30 N



THE CONSTELLATIONS AT 9 P. M. APRIL 1902.

A Total Eclipse of the Moon will take place April 22, but will be invisible in America. The beginning will be visible throughout Asia and the eastern parts of Europe and Africa; the ending visible throughout Europe, Asia and Africa.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension April 22, $7^h\ 00^m\ 54^s.9$.

	h	m	s				
Sun's right ascension	1	58	00.47	Hourly motion			$9^s.35$
Moon's right ascension	13	58	09.47	Hourly motion			120.20
Sun's declination	12°	04′	17″.2 N	Hourly motion		0′	50″.6 N
Moon's declination	12	19	25 .9 S	Hourly motion		7	51 .0 S
Sun's equa. hor. parallax			8 .7	Sun's true semidiameter		15	54 .3
Moon's " " "		54	40 .3	Moon's " "		14	53 .9

CIRCUMSTANCES OF THE ECLIPSE.

		h	m	
Moon enters penumbra	Apr. 22	3	49.0	Greenwich Mean Time.
Moon enters shadow		5	00.1	
Total eclipse begins		6	10.1	
Middle of eclipse		6	52.8	
Total eclipse ends		7	35.5	
Moon leaves shadow		8	45.5	
Moon leaves penumbra		9	57.0	

The Moon.

	Phases.	Rises. (Central Standard Time at Northfield Local Time 13m less.)		Sets.	
		h	m	h	m
Apr. 1	Last Quarter	12	59 A. M.	10	35 A. M.
8	New Moon	5	36 "	7	19 P. M.
14-15	First Quarter	10	44 "	1	35 A. M.
22	Full Moon	7	17 P. M.	5	42 "
30	Last Quarter	12	55 A. M.	11	17 "

Occultations Visible at Washington.

Date. 1902.	Star's Name.	Magnitude.	IMMERSION. Washington M.T.		Angle f'm N pt.	EMERSION. Washington M. T.		Angle f'm N pt.	Duration.	
			h	m	°	h	m	°	h	m
Apr. 13	26 Geminorum	5.0	10	29	105	11	24	279	0	55
14	68 Geminorum	5.0	7	02	167	7	43	227	0	41
16	ω Leonis	5.6	10	01	81	11	02	329	1	01
18	p^5 Leonis	5.5	13	30	119	14	35	286	1	05
20	28 Virginis	7.0	7	52	164	8	45	250	0	53
23	ν^2 Librae	6.9	7	24	41	7	49	354	0	25
24	ν Scorpii	4.2	17	43	150	18	19	210	0	36
29	B.A.C. 6992	6.2	15	17	52	16	38	277	1	21
29	β Capricorni	3.4	15	26	55	16	49	273	1	23

Sunspots.—During the past six months sunspots have been few and small. On March 4, however, after a week of cloudy weather, two considerable groups were seen in north latitude. Both consisted of scattered groups of small spots. Today (March 12) one group is to be seen near the west limb of the Sun. It consists of one large spot surrounded by an extensive area of faculæ.

Ephemeris for Physical Observations of the Sun.

[From the "Companion to the Observatory" for 1902.]

1902.	Greenwich Mean Noon.						1902.	Greenwich Mean Noon.					
	P		D		L			P		D		L	
	°	′	°	′	°	′		°	′	°	′	°	′
Jan. 1	+ 2	8	− 3	12	118	55	July 5	− 1	1	+ 3	27	197	8
6	− 0	19	3	46	53	5	10	+ 1	16	3	59	130	58
11	2	44	4	17	347	15	15	3	32	4	28	64	50
16	5	7	4	48	281	24	20	5	45	4	55	358	40
21	7	26	5	15	215	35	25	7	54	5	20	292	30
26	9	40	5	40	149	45	30	9	59	5	44	226	22
31	11	48	6	3	83	54	Aug. 4	11	59	6	5	160	14
Feb. 5	13	50	6	23	18	4	9	13	54	6	24	94	8
10	15	44	6	40	312	14	14	15	42	6	39	28	3
15	17	30	6	53	246	25	19	17	23	6	53	321	58
20	19	8	7	4	180	34	24	18	57	7	3	255	53
25	20	36	7	11	114	43	29	20	23	7	10	189	49
Mar. 2	21	56	7	14	48	51	Sept. 3	21	41	7	14	123	46
7	23	5	7	15	342	59	8	22	50	7	15	57	44
12	24	5	7	12	277	6	13	23	52	7	13	351	44
17	24	55	7	5	211	11	18	24	43	7	7	285	43
22	25	35	6	56	145	16	23	25	24	6	59	219	42
27	26	4	6	43	79	19	28	25	56	6	48	153	43
Apr. 1	26	22	6	28	13	22	Oct. 3	26	18	6	33	87	45
6	26	29	6	10	307	23	8	26	29	6	15	21	47
11	26	27	5	49	241	24	13	26	29	5	55	315	50
16	26	12	5	25	175	23	18	26	17	5	32	249	52
21	25	47	4	59	109	20	23	25	55	5	6	183	56
26	25	10	4	32	43	16	28	25	20	4	38	118	0
May 1	24	23	4	2	337	12	Nov. 2	24	34	4	8	52	4
6	23	24	3	30	271	7	7	23	25	3	36	346	8
11	22	15	2	57	204	59	12	22	25	3	2	280	13
16	20	56	2	24	138	51	17	21	4	2	28	214	18
21	19	27	1	49	72	43	22	19	31	1	50	148	24
26	17	49	1	13	6	34	27	17	48	1	13	82	30
31	16	2	0	37	300	24	Dec. 2	15	55	+ 0	36	16	36
June 5	14	8	− 0	1	234	14	7	13	53	− 0	4	310	43
10	12	6	+ 0	35	168	3	12	11	43	0	42	244	50
15	10	0	1	11	101	53	17	9	26	1	19	178	58
20	7	49	1	46	35	41	22	7	6	1	58	113	6
25	5	34	2	21	329	31	27	4	42	2	34	47	14
30	− 3	18	+ 2	55	263	20	32	+ 2	15	− 3	10	341	22

The position-angle of the Sun's axis, P, is the position-angle of the N. end of the axis from the N. point of the Sun, read in the direction N., E., S., W. In computing D (the heliographic latitude of the centre of the Sun's disk), the inclination of the Sun's axis to the ecliptic has been assumed to be 82° 45′, and the longitude of the ascending node to be 74° 24′. In computing L (the heliographic longitude of the centre of the disk), the Sun's period of rotation has been assumed to be 25.38 days, and the meridian which passed through the ascending node at the epoch 1854.0 has been taken as the zero meridian.

COMET AND ASTEROID NOTES.

Comet 1898 V, Definitive Orbit.—In *A. N.* 3770 Mr. Adolf Hnatek, of Vienna, gives the results of a definitive determination of the orbit elements of the

comet 1898 V, which was discovered by Giacobini at Nice. From six normal places extending from June 21 to Aug. 11 1898 the author finds parabolic elements which satisfy the observations satisfactorily. Assuming that the orbit is elliptic, he finds a period of 42043 years, but the elliptic elements do not represent the observations any better than the parabolic.

Elliptic Elements.	Parabolic Elements.
$T = 1898$ July 25.53945	$T = 1898$ July 25.533806 Berlin M. T.
$\omega = 313°\ 36'\ 51''.32$	$\omega = 313°\ 36'\ 34''.01$ }
$\Omega = 212\ 12\ 13\ .53$	$\Omega = 212\ 12\ 02\ .10$ } 1898.0
$i = 155\ 00\ 40\ .22$	$i = 155\ 00\ 42\ .90$ }
$a = 1209.2$	$\log q = 0.1764726$
$e = 0.9987588$	

New Asteroids.—The following new asteroids have recently been discovered:

	Disc'd by	At	Local M. T.	R. A.	Decl.	Mag.
				h m s	° ′ ″	
1902 HO	Palisa	Vienna	Feb. 4 11 40	9 58 24.8	+14 47 54	12.0
1902 HP	Carnera	Heidelberg	12 9 34	8 51 06	+31 35	11.

1902 HO was thought at first to be identical with (458) 1900 FK, but this identity is doubtful.

Numbering of New Asteroids.—In *A. N.* 3771 Dr. Bauschinger assigns permanent numbers to the following list of asteroids:

No.		Discovered by	Date.
(473)	1901 GC	Wolf	Feb. 13 1901
(474)	GD	Wolf	Feb. 13 1901
(475)	HN	Stewart	Aug. 14 1901
(476)	GQ	Carnera	Aug. 17 1901
(477)	GR	Carnera	Aug. 23 1901
(478)	GU	Carnera	Sept. 21 1901
(479)	HJ	Carnera	Nov. 12 1901

No. (476) has received the name Hedwig. 1901 GS has been identified with (453), 1901 GT probably with (156) Xanthippe, 1901 GV with 202 Chrysëis, 1901 GW with (247) Eukrate, and 1901 HG with (455) Bruchsalia. 1901 GX, GY, GZ, HA, HB, HC, HD, HE, HF, HH and HK were observed through so short intervals that elliptic orbits could not be computed.

Elements of Asteroid (477) 1901 GR.—Mr. E. Maubant of Paris gives the following elements in *A. N.* 3771:

Epoch 1901, Sept. 10, Paris Mean Time.

$M = 7°\ 11'\ 28''.5$		
$\omega = 318\ 00\ 41\ .9$ }		$\phi = 10°\ 56'\ 10''.2$
$\Omega = 10\ 58\ 30\ .6$ }	1900.0	$\mu = 955''.842$
$i = 5\ 12\ 21\ .8$ }		$\log a = 0.379747$

VARIABLE STARS.

Civil or Mean Time?—For the last few months we have been giving the times of the maxima and minima of variable stars in Greenwich civil time, following the example of the "Companion to the Observatory" and the "Annuaire du Bureau des Longitudes" from which sources most of the data concerning the variable stars are obtained. One of the American observers of variable stars objects strongly to the change from astronomical to civil time. As we desire only in publishing these tables, to serve those who make use of them, we should be glad to know if others would prefer to have us return to the use of astronomical mean time at Greenwich. Or, would the use of Central Standard time be still better?

Minima of Variable Stars of the Algol Type.

[Greenwich Mean Time beginning with midnight. The hours greater than 12 are those of the afternoon. To obtain Eastern Standard time subtract 5 hours; for Central Standard subtract 6 hours.]

U Cephei.

	d	h
Apr.	3	0
	5	12
	8	0
	10	11
	12	23
	15	11
	17	23
	20	11
	22	23
	25	10
	27	22
	30	10

Algol.

	d	h
Apr.	2	0
	4	21
	7	18
	10	14
	13	11
	16	8
	19	5
	22	2
	24	22
	27	19
	30	16

λ Tauri.

	d	h
Apr.	2	17
	6	16
	10	15
	14	14
	18	12
	22	11
	26	10
	30	9

R Canis Maj.

	d	h
Apr.	1	9
	2	12
	3	15
	4	19
	5	22
	7	1
	8	4
	9	8
	10	11
	11	14
	12	17
	13	20
	15	0
	16	3
	17	6
	18	10
	19	13

R Can. Maj. Cont.

	d	h
Apr.	20	16
	21	19
	22	23
	24	2
	25	5
	26	9
	27	12
	28	15
	29	18
	30	22

S Cancri.

	d	h
Apr.	4	12
	14	0
	23	11

S Antliæ.

Period $7^h\ 46^m.8$

	d	h
Apr.	1	12
	2	11
	3	10
	4	10
	5	9
	6	8
	7	8
	8	7
	9	6
	10	6
	11	5
	12	4
	13	4
	14	3
	15	2
	16	2
	17	1
	18	1
	19	0
	19	23
	20	23
	21	22
	22	21
	23	21
	24	20
	25	19
	26	19
	27	18
	28	17
	29	17
	30	16

δ Libræ.

	d	h
Apr.	2	21
	5	5
	7	13

δ Libræ Cont.

	d	h
Apr.	9	20
	12	4
	14	12
	16	20
	19	4
	21	12
	23	20
	26	3
	28	11
	30	19

U Coronæ.

	d	h
Apr.	3	20
	7	7
	10	18
	14	5
	17	16
	21	3
	24	13
	28	0

U Ophiuchi.

	d	h
Apr.	1	17
	2	13
	3	9
	4	5
	5	1
	5	21
	6	18
	7	14
	8	10
	9	6
	10	2
	10	22
	11	18
	12	14
	13	11
	14	7
	15	3
	15	23
	16	19
	17	15
	18	11
	19	8
	20	4
	21	0
	21	20
	22	16
	23	12
	24	8
	25	4
	26	1
	26	21

U Ophiuchi Cont.

	d	h
Apr.	27	17
	28	13
	29	9
	30	5

Z Herculis.

	d	h
Apr.	1	21
	3	20
	5	20
	7	19
	9	20
	11	19
	13	20
	15	19
	17	20
	19	19
	21	19
	23	18
	25	19
	27	18
	29	19

RX Herculis.

	d	h
Apr.	1	9
	2	7
	3	4
	4	1
	4	22
	5	19
	6	17
	7	14
	8	11
	9	9
	10	6
	11	4
	12	1
	12	22
	13	20
	14	17
	15	14
	16	12
	17	9
	18	6
	19	4
	20	1
	20	22
	21	20
	22	17
	23	14
	24	12
	25	9
	26	6
	27	4

RX Herculis Cont.

	d	h
Apr.	28	1
	28	23
	29	21
	30	18

V^3 Cygni

	d	h
Apr.	6	8
	12	8
	18	8
	24	8
	30	8

U^3 Cygni.

	d	h
Apr.	3	21
	8	11
	13	1
	17	14
	22	4
	26	18

W Delphini.

	d	h
Apr.	3	7
	8	3
	12	22
	17	17
	22	13
	27	8

Y Cygni.

	d	h
Apr.	2	5
	3	13
	5	5
	6	13
	8	5
	9	13
	11	5
	12	13
	14	4
	15	12
	17	4
	18	12
	20	4
	21	12
	23	4
	24	12
	26	4
	27	12
	29	4
	30	12

Variable Stars of Short Period not of the Algol Type.

	Minimum.	h	Maximum.	h		Minimum.	h	Maximum.	h
W Sagittarii	Apr. 1	8	Apr. 4	8	β Lyrae	Apr. 15	5	Apr. 18	7
β Lyrae	2	7	5	9	W Sagittarii	16	12	19	12
W Geminorum	2	16	5	7	U Sagittarii	16	18	19	17
Y Sagittarii	3	0	4	19	U Aquilae	17	22	20	2
U Sagittarii	3	6	6	5	W Geminorum	18	3	20	18
δ Cephei	3	7	4	22	T Vulpeculae	18	14	19	23
W Virginis	3	21	12	1	η Aquilae	18	21	21	3
U Aquilae	3	21	6	1	X Sagittarii	18	23	21	20
η Aquilae	4	12	6	18	δ Cephei	19	10	21	1
X Sagittarii	4	23	7	20	Y Sagittarii	20	8	22	3
ζ Geminorum	5	0	10	0	W Virginis	21	4	29	8
T Vulpeculae	5	7	6	16	β Lyrae	21	16	25	1
S Sagittae	6	9	9	19	Y Ophiuchi	22	3	28	8
δ Cephei	8	16	10	7	T Vulpeculae	23	1	24	10
β Lyrae	8	18	12	3	S Sagittae	23	3	26	13
Y Sagittarii	8	19	10	14	U Sagittarii	23	12	26	11
W Sagittarii	8	22	11	22	W Sagittarii	24	2	27	2
T Vulpeculae	9	17	11	2	δ Cephei	24	18	26	9
U Sagittarii	10	0	12	23	U Aquilae	24	23	27	3
W Geminorum	10	9	13	0	ζ Geminorum	25	7	30	7
U Aquilae	10	21	13	1	W Geminorum	25	21	28	12
η Aquilae	11	17	13	23	η Aquilae	26	1	28	7
X Sagittarii	11	23	14	20	T Monocerotis	26	1	May 4	0
X Cygni	14	0	20	19	Y Sagittarii	26	2	27	21
δ Cephei	14	1	15	16	T Vulpeculae	27	11	28	20
T Vulpeculae	14	4	15	13	β Lyrae	28	3	May 1	5
Y Sagittarii	14	13	16	8	δ Cephei	30	3	1	18
S Sagittae	14	18	18	4	U Sagittarii	30	5	3	4
ζ Geminorum	15	4	20	4	X Cygni	30	9	7	4

Maxima and Minima of U Pegasi.

[Period 4h 29m 8s; the minimum takes place 2h 15m after the maximum.]

	d	h		d	h		d	h		d	h
Apr.	1	21	Apr.	9	22	Apr.	17	19	Apr.	25	20
	2	19		10	21		18	22		26	19
	3	22		11	19		19	20		27	22
	4	21		12	22		20	19		28	20
	5	19		13	21		21	22		29	19
	6	22		14	19		22	20		30	22
	7	21		15	22		23	19			
	8	19		16	21		24	22			

Maxima and Minima of Long Period Variables.

[Computed from Chandler's "Third Catalogue" by Misses Ida I. Watson and Helen M. Swartz of Vassar College Observatory.]

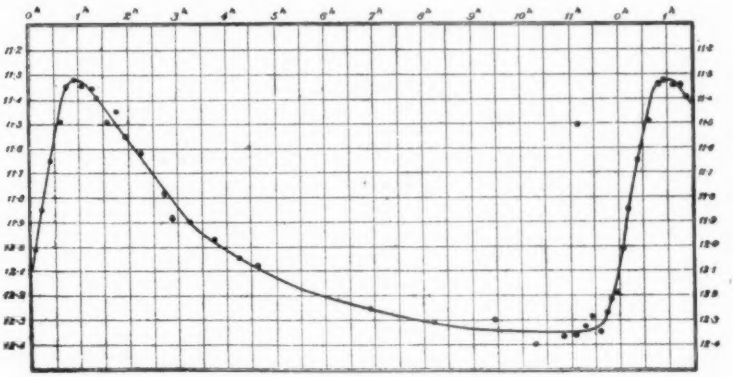
Maxima.			Minima.		
Date. April.	No.	Star.	Date April.	No.	Star.
7:	6943	T Sagittæ	2	6905	R Sagittarii
7:	7260	Z Aquilæ	4	513	R Piscium
11	1582	S Tauri	5	107	T Cassiopeæ
13	6132	R Ophiuchi	5	6512	T Herculis
13	7999	X Aquarii	9	1222	R Persei
14	5583	X Libræ	14	1717	V Tauri
16	5889	U Herculis	17	7468	T Aquarii
21	5931	S Ophiuchi	26	8591	V Cephei
23	8373	S Pegasi	29	7560	R Vulpeculæ
24	1386	T Eridani			
27:	2445	W Monocerotis			
27	7985	RT Cygni			

Variable Star 93.1901 Sagittæ.—In *A. N.* 3770 Mr. M. Ebell of Kiel, gives a new determination of the period of Schwab's new variable in Sagitta, depending upon 18 observations published by Professor E. C. Pickering in *Harvard College Observatory Circular*, No. 64 and the two by Parkhurst which were given in our last nnmber. Mr. Ebell finds for the period of the star $3^d\ 9^h\ 08^m\ 10^s.2$ and for an epoch of minimum 1901, Nov. 1 $6^h\ 37^m$ Gr. M. T. This represents very closely the thirteen Harvard photographs of the star which appear to have been obtained near times of minima during the last fifteen years. The following formula will enable anyone to predict future minima closely:

$$\text{Minimum} = 1901\ \text{Nov. } 1\ 6^h\ 37^m\ \text{Gr. M. T.} + 3^d\ 9^h\ 08^m\ 10^s.2E$$
$$= \text{J. D. } 2415690.276 + 3^d.380674E.$$

The Period of TX Cygni.—In *A. N.* 3769 Mr. A. Stanley Williams gives the results of a new determination of the period of this variable star, making the period to be 14.726 days. The magnitude of the star at maximum is not far from 8.5 and the range of variation about 1.2^m. The rise from minimum is at first gradual, but becomes very rapid towards the end; the fall from maximum to minimum taking 9.6 days, and the rise from minimum to maximum 5.1 days. Future maxima during 1902 should occur on: April 10.1, 24.8; May 9.6, 24.3; June 8.0, 22.7; July 7.5, 22.2; Aug. 5.9, 20.7; Sept. 4.4, 19.1; Oct. 3.8, 18.6; Nov. 2.3, 17.0; Dec. 1.7, 16.5 and 31.2. The star BD + 42°3935, R. A. $20^h\ 54^m\ 45^s.9$; Decl. + 42° 02′.1 (1855).

Period and Light Curve of Y Lyræ.—In *Monthly Notices* of the Royal Astronomical Society for January Mr. A. Stanley Williams gives results of his recent observations of this star which he discovered in 1900. It was then thought that the period was about 42 days or perhaps half that value, but it now turns out that the period is only a little over twelve hours. The star is



Light Curve of Y Lyræ.

only of the eleventh magnitude at brightest and for the greater part of the time is of about the twelfth magnitude. Mr. Williams' light curve shows the rise to maximum to be very abrupt and the decline to be more gradual. It is thus quite similar to the "cluster type" of variables, many of which were found by Professor Bailey to have periods of approximately one half day. This however, is an isolated star, showing that this type of variable is not confined to clusters.

ELEMENTS OF Y LYRÆ.

Period of variation	$0.5026876^d = 12^h03^m52.^s21$
Epoch of maximum	1901 Sept. 4, $13^h\ 20^m$ Gr. M. T. J. D. 2415632.5554
Maximum brightness	11.32^m
Minimum "	12.35
Minimum to maximum	$1^h\ 40^m$
Maximum to minimum	10 24

The place of the star for 1900 is R. A. $18^h\ 32^m\ 51^s$; Decl. $+ 43°\ 49'.6$. It is about $3\frac{1}{3}'$ northeast of the 8^m star BD 43°3029 (A on the accompanying chart).

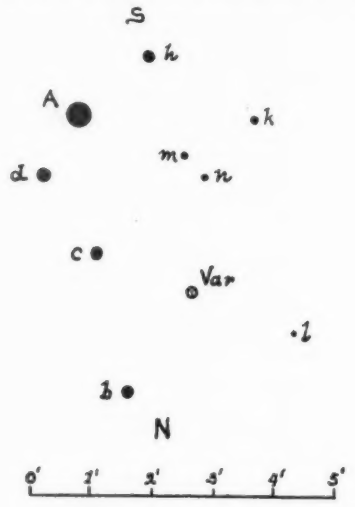


CHART OF THE STARS NEAR Y LYRÆ.

Mr. Williams gives the following adopted values for the light of the comparison stars:

Star.	Step Value.	Adopted Mag.	Star.	Step Value.	Adopted Mag.
c	0.0	10.80	*m*	14.8	11.75
h	5.5	11.09	*n*	18.1	11.99
k	13.0	11.63	*l*	19.7	12.10

The star *l* and the variable are equal in brightness about one hour before maximum. The computed times of this coincidence of brightness with star *l* for the next few months are given in the following table:

1902 Gr. M. T.	h	m	1902 Gr. M. T.	h	m	1902 Gr. M. T.	h	m
April 1	3	6	June 30	14	43	Sept. 18	0	54
11	4	23	July 10	16	00	28	2	11
21	5	41	20	17	17	Oct. 8	3	29
May 1	6	58	30	18	35	18	4	46
11	8	16	Aug. 9	19	52	28	6	04
21	9	33	19	21	10	Nov. 7	7	21
31	10	50	29	22	27	17	8	38
June 10	12	08	Sept. 8	23	44	27	9	56
20	13	25						

In the "Companion to the Observatory" this star is designated X Lyræ. Mr. Williams does not give the reason for changing the notation.

Observations of Nova Persei.—The following observations were made by H. C. Wilson with the aid of a pair of field glasses of 1½ inches aperture. The Nova was seen distinctly at all times and its fluctuations of light appear to have been very slight as compared with those in April and May:

OBSERVATIONS OF THE LIGHT OF NOVA PERSEI.

1901	Gr. M. T. h m	Comparisons.	Mag. m
Aug. 5	17 40	*I* 4 (71) 1 (72) 1 N 9 (83) 5 (85)	5.54
7	18 20	*I* 3 (71) 2 (72) 2 N 3 (85) 10 (85) 5 (87)	5.72
12	17 50	*I* 2 (71) 3 (72) 5 (83) 2 N 10 (85) 5 (87)	6.10
14	20 20	*I* 2 (71) 5 (72) 5 (83) 1 N 5 (85) 5 (87)	6.31
19	20 20	*I* 2 (71) 3 (72) 5 (83) = N 5 (85) 10 (87)	6.09
20	21 00	*I* = (71) 5 (72) 1 (83) = N 5 (85) 10 (87)	5.89
22	21 00	*I* 2 (71) 3 (72) 1 (83) 1 N 5 (85) 10 (87)	5.96
30	18 00	*I* 2 (71) 5 (72) 1 (83) 3 N 3 (85) 10 (87)	6.20
Sept. 5	15 05	*I* 1 (71) 2 (72) 4 N 1 (83) 5 (85) 5 (87)	6.02
20	15 05	*I* 1 (71) 2 (72) 5 N 1 (83) 5 (85) 5 (87)	6.08
25	15 05	*I* = (71) 5 (72) 5 (83) 1 N 5 (85) 10 (87)	6.17
Oct. 1	14 25	*I* 3 (71) 7 (72) 2 (83) 5 N 5 (85) 10 (87)	6.32
3	14 30	*I* 3 (71) 2 (72) 5 (83) 3 N 2 (85) 5 (87)	6.54
4	14 00	*I* 2 (71) 3 (72) 5 (83) 1 N 5 (85) 5 (87)	6.16
12	13 35	*I* 1 (71) 3 (72) 3 (83) 5 N 5 (85) 10 (87)	6.26
15	15 05	*I* 1 (71) 3 (72) 3 (83) 3 N 5 (85) 10 (87)	6.16
16	13 50	*I* 1 (71) 3 (72) 3 (83) 5 N 5 (85) 10 (87)	6.26
21	15 80	*I* 3 (71) 1 (72) 5 (83) 5 N 2 (85) 10 (87)	6.44
29	13 00	*I* 2 (71) 3 (72) 5 (83) 5 N 5 (85) 10 (87)	6.38
31	13 42	*I* 3 (71) 3 (72) 5 (83) 5 N = (85) 10 (87)	6.57
Nov. 1	.....	*I* 2 (71) 2 (72) 3 (83) 5 N = (85) 10 (87)	6.49
8	14 05	*I* 3 (71) 5 (72) 1 (83) 7 N 1 (85) 10 (87)	6.50
12	14 35	*I* = (71) 3 (72) 1 (83) 10 N 3 (85) 10 (87)	6.46
Dec. 30	15 35	*I* 7 (71) 3 (72) 5 (83) 10 (85) 5 N 5 (87)	7.07

The numbers in parentheses are the numbers of the comparison stars given in POPULAR ASTRONOMY Oct. 1901, p. 453-4. The magnitudes there adopted for (72), (83), (85) and (87) do not satisfy the observations very well. From the mean of all the observations I find the following magnitudes for the six stars:

I	32 Persei	5^m.15	(83) DM 44°,734	5^m.99
(71)	36 Persei	5 .33	(85) DM 43 ,730	6 .65
(72)	30 Persei	5 .63	(87) DM 43 ,732	7 .46

There is some evidence of variability among the comparison stars, but it is too slight to be decisive. Only in one case does the residual from the mean exceed 0^m.25. The star (71), which has been noted as variable by other observers, seems to be the least variable of them all according to these observations.

A second reduction, using the magnitudes given above for the comparison stars, does not change the results for the Nova perceptibly.

Proper Motion of Nova Persei.—In *A. N.* 3769 Mr. Ö Bergstrand, of the Upsala Observatory gives results of measures of the position of the Nova on plates taken on Sept. 1 and 11, Oct. 29, Nov. 21, 1901 and on Jan. 4 and 18, 1902. These indicate no certain change in the position of the star, either from proper motion or parallax. It would seem that the latter cannot be as great as 0″.1.

The Nova Persei Nebula.—The following telegram was received from Professor E. C. Pickering on March 14: "Hussey telegraphs from recent Crossley photograph Perrine finds no evidence of polarization in condensations *a* and *b* nebula surrounding Nova Persei." This is important as tending to show that the nebula shines by its own light rather than by the reflected light from the star.

New Variable Star 1. 1902 Cygni.—In *A. N.* 3771 Mr. A. Stanley Williams announces another new variable, similar to the "cluster Type" although it is an isolated star. Its position is approximately: R. A. $20^h\ 50^m\ 23^s$; Decl. $+\ 29°\ 52'.6$ (1855); and is in the same low power field with 96.1901 Cygni. The period is $13^h\ 26^m\ 19^s.59$. "The star rises with great rapidity and very abruptly from minimum to maximum in $1^h\ 55^m$, though the greater part of the change occurs in the first hour. Immediately after attaining maximum the decline sets in, and this is at first nearly as rapid as the rise, whilst during the last half of the period the star remains almost stationary at minimum brightness."

PROVISIONAL ELEMENTS.

Period = $0^d.559949$	$= 13^h\ 26^m\ 19^s.59$
Epoch of maximum	= 1901 Dec. 19 $9^h\ 39^m$ Gr. M. T.
	= J. D. 2415738.402
Maximum magnitude	= 9.65
Minimum magnitude	= 10.40
Minimum to maximum	= $1^h\ 55^m$
Maximum to minimum	= 11 31

The following ephemeris is for every tenth maximum during the summer and autumn months of this year.

	Gr. M. T.				Gr. M. T.				Gr. M. T.		
		h	m			h	m			h	m
June	5	9	17	Aug.	5	23	33	Oct.	6	13	49
	10	23	40		11	13	56		12	4	12
	16	14	03		17	4	19		17	18	36
	22	4	26		22	18	43		23	8	59
	27	18	50		28	9	06		28	23	22
July	3	9	13	Sept.	2	23	29	Nov.	3	13	45
	8	23	36		8	13	53		9	4	08
	14	13	59		14	4	16		14	18	32
	20	4	23		19	18	39		20	8	55
	25	18	46		25	9	02				
	31	9	09		30	23	26				

GENERAL NOTES.

The editors of this magazine do not endorse all the views of correspondents published from time to time. Positions of writers that are manifestly wrong appear only by mistake or oversight. It has been thought best to give large liberty of view on questions of doubt in the various lines of astronomical research, that scholarly investigations and writers may not be unduly hampered in any useful work they wish to pursue.

In some of the recent discussions that have appeared in our pages, we have regretted to print criticisms because they were unkindly severe to opponents who have not meant to be wrong in the views they maintained. They may have been careless or hasty in preparing manuscript for publication, and, in so far were unfortunate and possibly blameworthy in some degree; but not, we think, to the degree of severe censure. Will our correspondents think about this matter more carefully as they write in the future.

A Cosmic Cycle.—In the March number of *The American Journal of Science*, (p. 185), Frank W. Very continues his article on a Cosmic Cycle. He writes about the concluding stages of stellar growth, legitimacy of the hypothesis of elemental destruction and genesis of vortex atom as a possible solution,

relative abundance and distribution of the elements, properties of the luminiferous ether, and finally solar sustentation. His references to Lockyer's meteoritic hypothesis, to Wood's attempt to discover the properties of ether, Lane's theory of the Sun's density, Lord Kelvin's age of the Earth, and See's time of the Sun's past duration will give some idea of the breadth of view and the grasp of thought that Professor Very has put into this important paper.

Astronomical Photographic Work at Goodsell Observatory.—While the preparations were being made for the Pan-American Exposition at Buffalo, New York, Carleton College was asked to furnish an exhibit to be shown in the Minnesota State Building which was to be erected on the exposition grounds. The college authorities asked those in charge of Goodsell Observatory to prepare an exhibit that should at least represent some part of the work of the institution in scientific lines. As the officers in charge of Minnesota State exhibit could allow only 100 square feet of wall surface for the display of the scientific work of Carleton College, it was decided to represent the same by photography under the special direction of one of the Professors of the College, Dr. H. C. Wilson. The exhibit consisted of a large number of fine photographs taken by Dr. Wilson of the grounds and buildings on the campus, some inside views, groups of students in different departments of the College, Observatory views, and astronomical instruments showing the present working equipment of Goodsell Observatory. A large part of the exhibit consisted of astronomical photographs mounted on gray card-board which made a neat and unobtrusive background for the splendid pictures of the nebulæ, star-clusters, planet trails, star-trails, portions of the Galaxy, star clouds, and a great variety of Sun and Moon pictures that were intended to show the details for study of these most interesting celestial bodies. From many sources the college has been congratulated on the success of this astronomical exhibit.

By request of the officers of the State Teachers' Association this exhibit was shown at the last meeting of the Association, held in St. Paul during the last holiday season. By a similar request the exhibit will be shown at Alexandria this month, at the meeting of the Northern Minnesota Educational Association appointed for that time and place.

Electric Break Circuit Chronometers.—Wm. Bond & Sons, 152 Boston, Mass., have been successful competitors with the makers of other chronometers recently. At a trial of chronometers at the Government Observatory, in Washington in 1901, one of the Bond chronometers stood at the head of the list and two others were second.

The Bonds have recently furnished a break circuit chronometer for the Observatory of Columbia University in New York City, and also three more for a private Observatory in New York City.

Over fifty of these fine break circuit chronometers are now in use by different government offices, in universities, colleges, observatories and by railroad companies where accurate time-keeping is important. The break circuit attachment works admirably as shown by No. 374 of the Bond make belonging to Goodsell Observatory of Carleton College.

New Spectroscopic Binaries.—W. S. Eichelberger's brief abstract of Professor W. W. Campbell's paper read at the last meeting of the Astronomical and Astrophysical society is apparently so well done that it is difficult to con-

dense it further without leaving out important parts of the paper. We quote from *Science* Feb. 21, p. 295:

"Four stars have recently been observed with the Mills spectrograph to have variable velocities in the line of sight. These are ϕ Persei, ξ Herculis, α Equulei and o Andromedæ. The first of these is an interesting bright-line star. The second has a large radial velocity, and is moreover an interesting visual double star whose period is about 33 years. This therefore affords another connection between visual and spectroscopic binaries. In the case of the third star, a composite spectrum was observed a few years ago by Miss Maury at Harvard College Observatory. Thirty-two spectroscopic binaries discovered with the Mills spectrograph in the past three years had previously been announced, thus bringing the number up to 36. On the list of suspected binaries are 14 stars, awaiting confirmation. Before the discovery of these binaries, 3 had been found in the same list of stars by Belopolsky, making about 40 spectroscopic binaries in 325 stars observed. The proportion is therefore one spectroscopic binary for every eight stars observed. The variable velocity of our Sun, due to its revolving planets, has a double amplitude of only a few hundredths of a kilometer. As the work progresses and the degree of accuracy attainable increases, we shall probably find that there is a regular gradation of double amplitudes from that of our Sun up to those of the spectroscopic binaries already discovered, and it is possible that the star that is not a spectroscopic binary will prove to be the rare exception. This field of investigation is one of extreme richness."

The Constant of Aberration.—As reported in *Science* (February 21), Professor C. L. Doolittle gives work done at Flower Observatory on the constant of aberration as follows:

1896—98	20″.580
1899—99	20 .542
1900—01	20 .560

J. W. J. A. Stein, Leiden, using the zenith telescope:

1899—1900 20″.541 ± 0.016

Chandler as derived from Pond's observations:

1825—36 20″.512 ± 0.019

Albrecht, International latitude.

20″.515.

Leonids Observed at Lawrence University, Appleton, Wis.—Professor P. W. Jenkins of the Underwood Observatory promptly sent the following observations of the Leonids of last Nov., but it has been impossible to present earlier considerable of the matter that reached us after the November display because there has been so much of it that was really useful. Professor Jenkins' report is as follows:

Out of 67 meteors observed 51 were certainly Leonids. In the first half of the watch the average interval was 10 minutes and in the last half 3 minutes. Nearly all were faint and left very little train, burning out quickly. It would appear that the particles were very small. It will be seen from the table that they fell in groups at intervals of a few minutes. It appears from reports and from our own observations that the Earth was central in the stream on the 15th which would indicate that the orbit had shifted but little.

In the table L = Leonid, y = yellow, w = white, r = red, J = Jenkins and M = Mead.

90th Meridian. Time.			Mag.	Leon.	Color.	Obs'r.	90th Meridian. Time.			Mag.	Leon.	Color.	Obs'r.
h	m	s	s				h	m	s				
12	28	30	4	—	y	J	3	29	0	6	—	—	J
	28	40	5	L	y	J		30	30	5	L	y	J
	45	10	4	—	w	M		33	40	5	L	w	J
	45	50	5	—	y	M		36	30	4	L	w	J
	48	8	6	—	—	M		42	15	5	—	w	M
	53	0	5	L	w	M		45	10	5	L	w	J
	57	1	4	L	y	M		50	30	5	L	y	M
1	4	40	5	L	w	J		51	5	5	E	w	M
	12	40	4	—	w	J		52	20	6	L	w	M
	14	20	6	L	—	J		53	15	6	L	w	M
	22	50	5	—	y	M		55	30	4	L	w	J
	26	52	6	L	y	M		55	50	5	L	w	M
	27	5	6	L	y	M		56	25	5	L	w	M
	38	58	6	L	w	J		58	0	5	L	w	M
	42	5	4	L	y	J	4	0	25	4	L	w	M
	45	0	5	L	y	M		1	30	6	L	w	J
	57	40	5	L	w	M		3	0	5	L	w	M
	58	30	5	—	w	M		3	40	4	—	w	M
2	19	15	6	L	—	M		4	35	6	L	w	J
	21	20	6	—	w	M		5	5	6	L	w	J
Interval 30^m			—	—	—	—		5	20	5	—	w	J
3	2	25	4	L	w	J		5	25	6	L	w	J
		50	5	L	w	J		5	45	5	L	w	J
	3	45	4	L	w	J		6	15	6	L	w	J
	7	30	6	L	w	J		6	35	5	L	w	J
	9	50	6	L	w	M		12	40	5	L	w	J
	10	5	4	L	w	J		14	0	6	—	y	J
	11	45	5	—	—	J		16	20	6	L	w	M
	14	0	5	—	w	J		18	50	5	L	w	M
	18	45	4	L	w	J		18	55	6	L	w	M
	18	46	5	L	w	M		19	30	5	L	w	M
	19	20	5	L	w	M		27	0	5	L	w	M
	24	32	6	L	w	M		31	40	5	L	y	J
	28	10	6	L	w	M		35	0	−2	—	y	J

The British Journal of Photography for the year 1902 is enlarged and improved. It is one of the best magazines in the line of photography. The February number contains a four page article on the geometric interpretation of photographs as applied to surveying and other purposes. This paper was read before the civil and engineers' society, date and place not being mentioned. The purpose of the paper is to point out the advantages of photography in surveying work which has as yet come into very limited use.

Total Solar Eclipse of the Sun 1905.—A brief but very helpful article on the total eclipse of the Sun Aug. 30, 1905 is given in Vol. XII, No. 4, of the *Journal of the British Astronomical Association* by G. F. Chambers. This eclipse path starts in the north of Canada, crosses Spain from northwest to southeast. From Spain the path will run near Malta to Egypt, and thence nearly to the Indian Ocean west of the Persian Gulf. The comparatively long duration of the period of totality of this eclipse makes it the most important one of the first quarter of the twentieth century as regards western Europe, if the data now at hand is correct. Later fuller information will be given concerning the circumstance of this eclipse in Canada which may especially interest American readers.

The Moon and Thunderstorms.—A note with diagrams to illustrate observed data, showing the relation of thunderstorms to the age or phase of the Moon is given in *Nature*, February 20, 1902, page 367. The note was prepared by Alex. B. MacDowall of Sidmouth, and gives the results of observations for 13 consecutive years. The observations consisted in noting on what days thunder was heard and in relation to the weeks that belong to quarter phases of the Moon. The diagrams set forth the observations in the form of a curve platted in the usual way.

It is interesting to notice in this case that thunder was heard at Greenwich, England during the last 13 years most frequently in the week about the new Moon, and least often about half way between full Moon and the last quarter. A marked difference appears between the two three-day groups just referred to in the above comparison. The three-day group commencing with second day after full Moon is represented by the number 9, while the group about new Moon is represented by 32.

British Mathematicians of the Nineteenth Century.—We notice with interest that Dr. Alexander Macfarlane is to deliver a course of lectures at Lehigh University on British mathematicians of the nineteenth century. The course was to begin March 14 and end March 25. This course of six lectures will respectively present the work of James Clerk Maxwell, Henry John Stephen Smith, William John Macquorn Rankin, James Joseph Sylvester, Peter Guthrie Tait and William Thompson (Lord Kelvin).

It would be a source of help to many mathematicians if these lectures should appear later in printed form.

Reversal of the Photographic Image and Its Development in Actinic Light.—During the past year Professor Francis E. Nipher has presented several papers to the Academy of Sciences of St. Louis that have renewed general interest in sensitive silver salts and their behavior in the action of actinic light. The fact that silver salts have the property that makes them particularly susceptible to the action of reducing agents, and also that exposure to actinic light brings about a reversal, were facts that were known long before Professor Nipher had called attention to them. All that Professor Nipher claimed as original in his recent papers was the possibility of developing these reversed photographs in actinic light. This fact when first known appeared to be so different from that to which photographers were accustomed that it created wide-spread interest in study and experiment.

In a recent article in *The Journal of the Franklin Institute*, (March No., 1902, p. 231), this theme is taken up, and a detailed study of some experimental work given by M. I. Wilbert, a member of the Franklin Institute. Those interested in practical photography will find instructive matter in all these papers.

The Duration of Twilight within the Tropics.—S. I. Bailey's paper on the above topic given at the last meeting of the Astronomical and Astrophysical Society at Washington mentions an observation made at Vincocaya, Aug. 27, 1899, in latitude 16° south and an altitude 14,360 feet. Mr. Bailey says, "it was possible to read coarse print forty-seven minutes after sunset, and that twilight was seen for an hour and twelve minutes after the Sun's disappearance."

The Period of Delta Equulei.—W. J. Hussey of Lick Observatory from recent work on the period of Delta Equulei says, the data at present available appears to show that the period of 5.7 years is substantially correct.

Anonymous Fund of 1902.—An anonymous gift of $20,000, for the benefit of Harvard College Observatory, has just been received from a friend of the undersigned. The value of this gift has been greatly increased by the fact that no restrictions have been placed by the donor on its expenditure. As it was wholly unexpected and unsolicited, my pleasure has not been marred by the thought that it might have been given with reluctance.

A very urgent need of the Observatory will be relieved at once by this gift. The building provided, nine years ago, for the astronomical photographs has become wholly inadequate to contain them, owing to their continual and rapid growth. It is proposed to expend about one-half of this fund in extending the present building, by the erection of a wing to the east, which will provide for the adequate storing of this collection with its probable increase for many years. These photographs furnish a history of the entire stellar universe for the last twelve years, which is not duplicated elsewhere. Whenever a new object is discovered in any part of the sky, we are therefore able to study its past history during this period. Evidently, provision should be made for extensive use of this collection by large numbers of astronomers. A much larger building, staff and endowment, than our present means permit, would be required for this purpose. Accordingly, the new wing will be so constructed that when these plans are carried out, it can be used for holding the valuable collection of astronomical books (one of the most complete in the world) belonging to the Observatory. These books are now contained in a wooden building fifty years old, and are in danger of destruction by fire at any time.

The remainder of the fund will be expended from time to time as urgent needs occur. It is proposed to employ a portion of it at once in studying new objects of interest on the photographs, since without it we have hitherto only been able to examine those of special importance. The value of a fund which will provide for such emergencies must be obvious. The larger plans described above, I hope, indicate the healthy and insatiable appetite of an institution which is always attempting to reach out into untrodden fields, and in which each accession suggests opportunities of still further extending its work into the unknown.

EDWARD C. PICKERING.

CAMBRIDGE, Mass., U. S. A.
March 10, 1902.

Director Harvard College Observatory.

Some Fallacies in Wentworth's Geometry.—By all means teachers of geometry should read an article in the February number of *The American Mathematical Monthly*, (p. 37) under the above title. If such readers do, or do not, understand American-French, so-called, either condition will not hinder a genuine relish of the introduction to the article. The criticisms are very suggestive.

The Singkep Mechanical Commutator.—*The Journal of the British Astronomical Association*, Vol. XII, No. 4, contains an interesting description, by Professor David P. Todd, of a peculiar commutator used by him for operating various instruments automatically at the time of the total eclipse in 1901, observed from the Island of Singkep. The whole apparatus was devised at Singkep and constructed from material found there.

Annuaire du Bureau des Longitudes 1902.—This is a convenient little handbook published by the Bureau of Longitudes of France. It contains an almanac giving the principal astronomical data for the year, tables of weights and measures, of different moneys, and various statistics, as well as tables of

physical and chemical data. There are also notices on "Wirelesss telegraphy," by M. H. Poincaré, "Multi-phase Currents," by M. A. Cornu, "On the application of the decimal division of the quadrant to the practice of navigation" by M. E. Guyou, and "The Observatory on the summit of Mt. Blanc," by M. J. Janssen.

Elementary Treatise on Navigation and Nautical Astronomy.—Professor Eugene L. Richards of Yale University has recently prepared an elementary treatise on navigation and nautical astronomy. The book contains 173 pages and is the outcome of the author's own teaching. His method of instruction is based on a knowledge of elementary plane and spherical geometry and trigonometry and the examples are worked out by means of Bowditch's Useful Tables, published by the United States Government; the corrections to middle latitude are copied from the same work in a two page reference table at the close of this book.

The author treats of plane sailing, middle latitude sailing, great circle sailing, causes, astronomical terms, time, the nautical almanac, the hour angle, corrections of altitude, latitude and longitude. A useful table of terms employed in nautical astronomy is found on page 140, and following.

This book has been prepared by a teacher of the subject matter presented. It is concise, clear, well illustrated and covers the ground admirably. It is published by the American Book Company of New York, Cincinnati & Chicago.

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